27839-1306
K-C 18,956

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of Davis-Dang Hoang Nhan Art Unit 3761
Serial No. 10/699,193
Filed October 31, 2003
Confirmation No. 3474
For STRETCHABLE ABSORBENT ARTICLE
Examiner Melanie J. Hand

APPEAL BRIEF

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TABLE OF CONTENTS

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August 22, 2008

APPEAL BRIEF

This is an appeal from the final rejection of the claims of the above-referenced application made in the final Office action dated March 28, 2008. A Notice of Appeal was filed on June 23, 2008.

I. REAL PARTY IN INTEREST

The real party in interest in connection with the present appeal is Kimberly-Clark Worldwide, Inc. of 401 N. Lake Street, Neenah, Wisconsin 54957-0349, a corporation of the state of Delaware, owner of a 100 percent interest in the pending application.

II. RELATED APPEALS AND INTERFERENCES

Appellants are not aware of any pending appeals, which may be related to, directly affect or be directly affected by, or have a bearing on, the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-14, 17-21, and 114 are currently pending in the application for consideration. Claims 15, 16, and 22-29 were withdrawn from consideration and claims 30-113 were cancelled

during prosecution. A copy of the claims involved in this appeal appears in the Claims Appendix of this Brief.

Claims 1-14, 17-21 and 114 stand rejected.

The rejections of claims 1-4 and 17-21 are being appealed.

IV. **STATUS OF AMENDMENTS**

No amendments have been filed after the final rejection.

V. **SUMMARY OF CLAIMED SUBJECT MATTER**

The following summary correlates claim elements to specific embodiments described in the application specification, but does not in any manner limit claim interpretation. Rather, the following summary is provided only to facilitate the Board's understanding of the subject matter of this appeal.

With reference to the present specification and drawings, claim 1 is directed to an absorbent article 20 comprising a stretchable substrate 40 (or 42) and an absorbent composite 44. See paragraph [0041], page 10 and Figs. 4, 5 and 7-10. The absorbent composite 44 comprises a layer 202 of adhesive composition in contact with the stretchable substrate 40 (or 42) and a layer 204 of particulate superabsorbent material applied to and held by the adhesive composition. See paragraph [0064], page 21 and Figs. 4, 5 and 7-9. The absorbent composite 44 is secured to the substrate 40 (or 42) by the adhesive composition. See paragraph [0064], page 21 and Figs. 4, 5 and 7-9. The absorbent article 20 is stretchable. See paragraph [00122], page 48 and Figs. 11-13. The layer 204 of particulate superabsorbent material remains secured to the substrate 40 (or 42) by the adhesive upon stretching of the absorbent article 20. See paragraph [00122], page 48.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Appellants appeal the rejections of claims 1-4 and 17-21 under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,496,429 (Hasse et al.).

VII. ARGUMENT

A. Claims 1-4 and 17-21 are submitted to be unanticipated by and patentable over U.S. Patent No. 5,496,429 (Hasse et al.)

Claims 1-4, 17, 18 and 20

Claim 1

Claim 1 is directed to an absorbent article comprising:

a stretchable substrate; and

an absorbent composite comprising a layer of adhesive composition in contact with the stretchable substrate and a layer of particulate superabsorbent material applied to and held by the adhesive composition, the absorbent composite being secured to the substrate by the adhesive composition, the absorbent article being stretchable, the layer of particulate superabsorbent material remaining secured to the substrate by said adhesive upon stretching of the absorbent article.

Claim 1 is submitted to be unanticipated by and patentable over U.S. Patent No. 5,496,429 (Hasse et al.), in that Hasse et al. fail to show or suggest an absorbent article having 1) a stretchable substrate and 2) an absorbent composite comprising a layer of adhesive composition in contact with the stretchable substrate and a layer of particulate superabsorbent material applied to and held by an adhesive composition.

As shown in Figs. 2, 10 and 11, Hasse et al. disclose an absorbent article having a chassis 14 and an absorbent assembly 22, which is formed separate from and attached to the chassis.

The chassis 14 comprises an outer layer 48 and elastic ear flap members 90 secured inward of longitudinal side regions 88 of the outer layer. The absorbent assembly 22 comprises a topsheet 24, a backsheet 26 (characterized in the final Office action as the recited substrate), and an absorbent core 28 (characterized in the final Office action as the recited absorbent composite) sandwiched between the topsheet and the backsheet.

Hasse et al. fail to teach or suggest a stretchable substrate as recited in claim 1.

Nowhere do Hasse et al. disclose that the backsheet (26) disclosed therein is stretchable. Rather, Hasse et al. disclose that the backsheet can be formed from thermoplastic films of polyethylene or polypropylene. Based on this disclosure, the Office asserts that thermoplastic polyethylene is inherently "stretchable because it is an elastomeric material." See page 2 of the final Office action.

However, no evidentiary support is provided by the Office in support of its position. In fact, polyethylene and polypropylene films are not necessarily elastomeric or even stretchable. For example, see col. 16, lines 64 and 65 of U.S. Patent No. 6,521,085, which discloses a nonstretchable bag that can be made of polyethylene or polypropylene. See also col. 3, lines 32-34 of U.S. Patent No. 6,315,748, which discloses a nonstretchable polyethylene film.

In the passage cited by the Office (col. 20, lines 56-59), Hasse et al. teach that the backsheet is preferably manufactured from a polyethylene or polypropylene film. But at lines 48-53 Hasse et al. explain that this is to render the film flexible, which is not the same as stretchable. Thus, the Office's assumption that the backsheet disclosed by Hasse et al. must be

stretchable merely because it can be formed from polyethylene or polypropylene is unfounded and cannot be maintained.

Moreover, implicit in Hasse et al. is that the backsheet disclosed therein is nonstretchable. Particularly, Hasse et al. add that the elasticized leg cuffs (32) are free from the backsheet so that the backsheet *does not inhibit* the leg cuffs. See column 21, lines 1-8. In other words, the elasticized leg cuffs are unsecured to the backsheet of Hasse et al. because a non-stretchable backsheet would inhibit the leg cuffs from stretching. Thus, not only do Hasse et al. fail to teach or suggest that the backsheet is stretchable but they also infer that the backsheet is not stretchable.

Accordingly, Hasse et al. fail to teach or suggest a stretchable substrate as recited in claim 1.

Hasse et al. fail to teach or suggest a layer of particulate superabsorbent material applied to and held by an adhesive composition as recited in claim 1.

Hasse et al. also fail to disclose that the adhesive securing the absorbent core to the backsheet has a layer of particulate superabsorbent material applied to it as recited in claim 1. As noted by the Office, Hasse et al. at column 20, lines 20-25 discloses that the backsheet (26) can be adhesively secured to the absorbent core and it is recognized that the absorbent core of Hasse et al. can include superabsorbent polymers (see column 19, line 26) or absorbent gelling material as one of its components. Superabsorbent polymers and absorbent gelling material are most often used in absorbent cores in combination with other absorbent materials (e.g., wood pulp, cellulose wadding, coform) that are also disclosed in Hasse et al. In fact, Hasse et al. states that the "absorbent core 28 is preferably a batt of airfelt and particles of absorbent gelling

material." See column 19, lines 65-67. Typically, superabsorbent polymers and absorbent gelling material are dispersed throughout the airfelt and not arranged in a layer. For example, see paragraph [0004] of applicants' specification. For other examples, see U.S. Patent Nos. 4,610,678; 4,673,402; 4,834,735; and 4,888,231, which are disclosed by Hasse et al. as teaching exemplary absorbent structures that could be used as the absorbent core. See column 19, lines 50-65. Each of these patents discloses an absorbent core having a fibrous web with discrete hydrogel particles dispersed therein. Adhering a fibrous web having discrete hydrogel particles, superabsorbent polymers and/or absorbent gelling material dispersed therein to a backsheet does not anticipate claim 1. The particles dispersed in the web are not in a layer nor are they applied directly to and held by adhesive on the backsheet.

The Office has taken the position that if superabsorbent gelling material is the only material used to form the absorbent core of Hass et al., then Hasse et al. would necessarily teach that the superabsorbent gelling material is adhered in a layer to the substrate. See pages 2 and 3 of the final Office action. However, nowhere do Hasse et al. teach or even suggest that the superabsorbent gelling materials disclosed therein are used alone to form the absorbent core as opined by the Office. Rather, Hasse et al.'s disclosure, when taken as a whole, merely describes various conventional absorbent cores that may include superabsorbent gelling materials dispersed within other materials (e.g., airfelt). See col. 19 and 20 of Hasse et al.

As a result, Hasse et al. fail to teach or suggest a layer of particulate superabsorbent material being applied to and held by an adhesive composition as recited in claim 1.

For these reasons, claim 1 is submitted to be unanticipated by and patentable over Hasse et al. Claims 2-4, 17, 18, and 20 depend directly or indirectly from claim 1 and are submitted to be patentable over Hasse et al. for the same reasons as claim 1.

Claim 19

Claim 19 depends from claim 1 and further recites that the stretchable substrate is elastic. As asserted above with respect to claim 1, Hasse et al. do not disclose a stretchable substrate and therefore cannot disclose an elastic substrate. The passage of Hasse et al. relied on by the Office (i.e., column 20, lines 48-53) discloses that the backsheet may be formed from thermoplastic films of polyethylene or polypropylene. These films, as set forth above, are not necessarily stretchable and therefore are not necessarily elastic. Elastic means that upon application of an elongating force, a material (or substrate) is elongatable (i.e., stretchable) in at least one direction and retracts to dimensions close to its original dimensions (e.g., within at least about 25 percent) upon removal of the elongating force. See page 17, paragraph [0056] of the present specification. Thus, Hasse et al. fail to teach or suggest that the backsheet disclosed therein is elastic.

Accordingly, Hasse et al. fail to teach or suggest an elastic substrate as recited in claim 19. As a result, claim 19 is submitted to be further patentable over Hasse et al.

Claim 21

Claim 21 depends from claim 1 and recites, in part, that the absorbent article further comprises a second layer of particulate superabsorbent material being applied to and held by a second layer of adhesive composition. Since Hasse et al. fail altogether to disclose or suggest a layer of particulate superabsorbent material applied to and held by a layer of adhesive composition (as explained in detail with respect to claim 1), Hasse et al. must fail to disclose or suggest a second layer of particulate superabsorbent material being applied to and held by the second layer of adhesive composition.

Thus, claim 21 is submitted to be further patentable over Hasse et al.

CONCLUSION

For the reasons stated above, appellants respectfully request that the Office's rejections be reversed and that claims 1-29 and 114 be allowed.

Respectfully submitted,

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Via EFS

VIII. CLAIMS APPENDIX

1. An absorbent article comprising:

a stretchable substrate; and

an absorbent composite comprising a layer of adhesive composition in contact with the stretchable substrate and a layer of particulate superabsorbent material applied to and held by the adhesive composition, the absorbent composite being secured to the substrate by the adhesive composition, the absorbent article being stretchable, the layer of particulate superabsorbent material remaining secured to the substrate by said adhesive upon stretching of the absorbent article.

2. An absorbent article as set forth in claim 1 wherein the stretchable substrate is a first stretchable substrate, the absorbent article further comprising a second stretchable substrate in generally superposed relationship with the first stretchable substrate whereby the absorbent composite is disposed between said first and second stretchable substrates.

3. An absorbent article as set forth in claim 1 wherein the layer of adhesive composition is a first layer of adhesive composition, the absorbent article further comprising a second layer of adhesive composition applied to the layer of particulate superabsorbent material.

4. An absorbent article as set forth in claim 3 wherein the stretchable substrate is a first stretchable substrate, the absorbent article further comprising a second stretchable substrate in generally superposed relationship with the first stretchable substrate and secured to the second layer of adhesive composition to thereby secure the absorbent composite to said second stretchable substrate.

5. An absorbent article as set forth in claim 1 wherein the adhesive composition comprises a hot-melt adhesive.

6. An absorbent article as set forth in claim 1 wherein the adhesive composition has a viscosity of less than about 10,000 centipoises at a temperature of less than or equal to about 400 degrees Fahrenheit (about 204 degrees Celsius).

7. An absorbent article as set forth in claim 6 wherein the adhesive composition has a viscosity of less than about 10,000 centipoises at a temperature of less than or equal to about 300 degrees Fahrenheit (about 149 degrees Celsius).

8. An absorbent article as set forth in claim 7 wherein the adhesive composition has a viscosity of less than about

10,000 centipoises at a temperature of less than or equal to about 250 degrees Fahrenheit (about 121 degrees Celsius).

9. An absorbent article as set forth in claim 6 wherein the adhesive composition has a viscosity in the range of about 1,000 to about 8,000 centipoises at a temperature of about 300 degrees Fahrenheit (about 149 degrees Celsius).

10. An absorbent article as set forth in claim 9 wherein the adhesive composition has a viscosity in the range of about 2,000 to about 6,000 centipoises at a temperature of about 300 degrees Fahrenheit (about 149 degrees Celsius).

11. An absorbent article as set forth in claim 1 wherein the adhesive composition has a storage modulus (G’) of less than or equal to about $1.0x10^7$ dyne/cm^2 at 25 degrees Celsius.

12. An absorbent article as set forth in claim 11 wherein the adhesive composition has a storage modulus (G’) in the range of about $1.0x10^5$ to about $1.0x10^6$ dyne/cm^2 at 25 degrees Celsius.

13. An absorbent article as set forth in claim 6 wherein the adhesive composition has a storage modulus (G’) of less than about $1.0x10^7$ dyne/cm^2 at 25 degrees Celsius.

14. An absorbent article as set forth in claim 13 wherein the adhesive composition has a storage modulus (G') in the range of about $1.0x10^5$ to about $1.0x10^6$ dyne/cm^2 at 25 degrees Celsius.

17. An absorbent article as set forth in claim 1 wherein the absorbent composite further comprises hydrophilic fibers.

18. An absorbent article as set forth in claim 1 wherein the absorbent composite has a width and a length, said absorbent composite having a non-uniform basis weight across at least a portion of at least one of the width and the length of said absorbent composite.

19. An absorbent article as set forth in claim 1 wherein the stretchable substrate is elastic.

20. An absorbent article as set forth in claim 1 wherein the stretchable substrate defines an outer cover of the absorbent article, the absorbent article further comprising a liquid permeable liner in generally superposed relationship with the outer cover and adapted for contiguous relationship with the wearer's skin, the absorbent composite being disposed between the liner and the outer cover.

21. An absorbent article as set forth in claim 1 wherein the layer of adhesive composition is a first layer of adhesive composition and the layer of particulate superabsorbent material is a first layer of particulate superabsorbent material, the absorbent article further comprising a second layer of adhesive composition applied to the first layer of particulate superabsorbent material, the second layer of particulate superabsorbent material being applied to and held by the second layer of adhesive composition.

114. An absorbent article as set forth in claim 1 wherein the adhesive composition comprises at least one tackifier, said at least one tackifier comprising about 30 to about 65 percent by weight of the adhesive composition.

IX. EVIDENCE APPENDIX

U.S. Patent Nos. 6,521,085; 6,315,748; 4,610,678; 4,673,402; 4,834,735; and 4,888,231 are being relied on by the Appellants to support their positions set forth above. Each of these patents was previously relied on by Appellants in a Response to Office Action filed December 31, 2007.

X. RELATED PROCEEDINGS APPENDIX

None.

US006521085B2

(12) United States Patent
Kumamoto et al.

(10) Patent No.: US 6,521,085 B2
(45) Date of Patent: Feb. 18, 2003

(54) **PULP MOLDED ARTICLE**

(75) Inventors: **Yoshiaki Kumamoto**, Haga-gun (JP); **Kenichi Otani**, Haga-gun (JP); **Shinji Otakura**, Haga-gun (JP); **Tokuo Tsuura**, Haga-gun (JP); **Masataka Ishikawa**, Haga-gun (JP); **Toshiyuki Suga**, Haga-gun (JP); **Akira Nonomura**, Haga-gun (JP)

(73) Assignee: **Kao Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/885,982**

(22) Filed: **Jun. 22, 2001**

(65) **Prior Publication Data**

US 2001/0040016 A1 Nov. 15, 2001

Related U.S. Application Data

(62) Division of application No. 09/622,043, filed as application No. PCT/JP99/00775 on Feb. 22, 1999.

(30) **Foreign Application Priority Data**

Feb. 23, 1998	(JP)	10-40597
Feb. 23, 1998	(JP)	10-40697
Feb. 23, 1998	(JP)	10-40699
May 29, 1998	(JP)	10-186768
Sep. 17, 1998	(JP)	10-262970
Sep. 29, 1998	(JP)	10-275256
Dec. 28, 1998	(JP)	10-373716
Dec. 28, 1998	(JP)	10-373717
Feb. 5, 1999	(JP)	11-29290

(51) **Int. Cl.**^{7} **D21J 7/00**

(52) **U.S. Cl.** **162/130**; 162/149; 162/219; 162/228; 162/231; 428/34.2

(58) **Field of Search** 162/115, 116, 162/117, 13, 218–230, 387–416, 123–133, 231; 264/493, 495, 86, 87, 299, 301, 306, 313, 315, 319; 428/35.6, 542.8, 34.2

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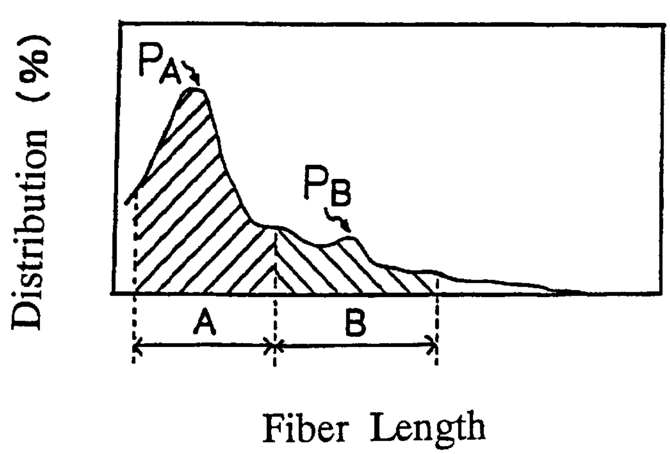
Primary Examiner—Steven P. Griffin
Assistant Examiner—Eric Hug
(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

A method for producing a pulp molded article (**7**) comprising the steps of supplying a pulp slurry into the cavity (**1**) of a mold (**10**) composed of a set of splits (**3** and **4**) the set of splits (**3** and **4**) being assembled together to form the cavity (**1**) with a prescribed configuration, to form a pulp deposited body (**5**), feeding a fluid into the cavity (**1**) to press the pulp deposited body (**5**) onto the inner wall of the cavity (**1**) for dewatering.

3 Claims, 10 Drawing Sheets



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U.S. patent application Ser. No. 09/885,982, Kumamoto, filed Jun. 22, 2001, pending.

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Fig.1 (a)

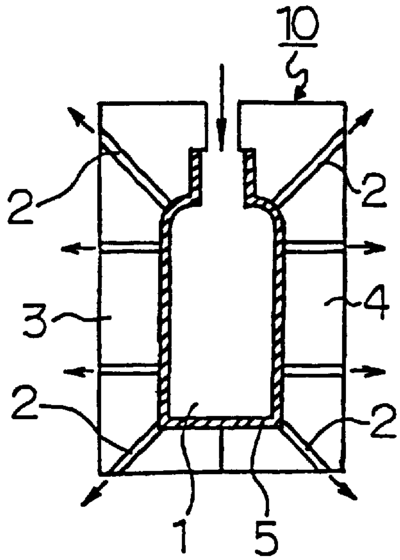

Fig.1 (b)

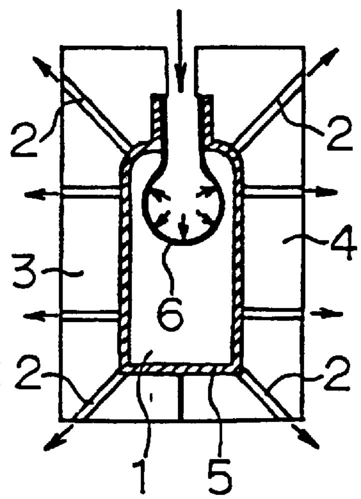

Fig.1 (c)

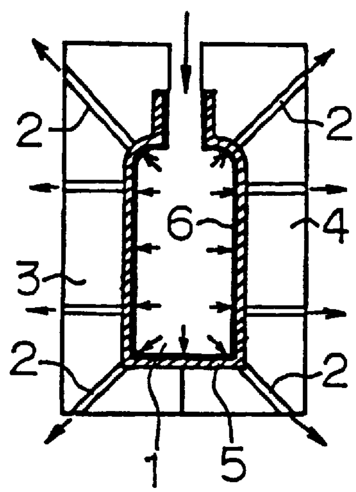

Fig.1 (d)

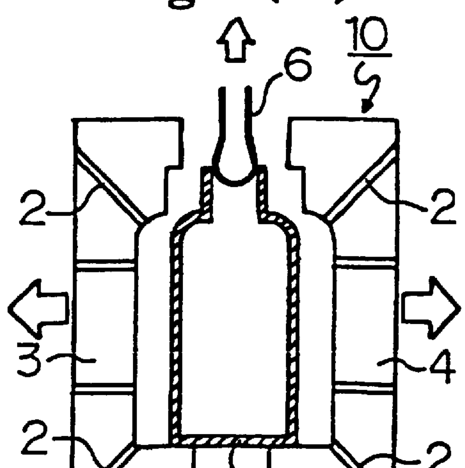

Fig.1 (e)

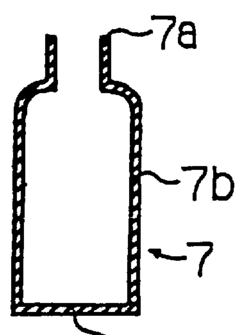

Fig.2

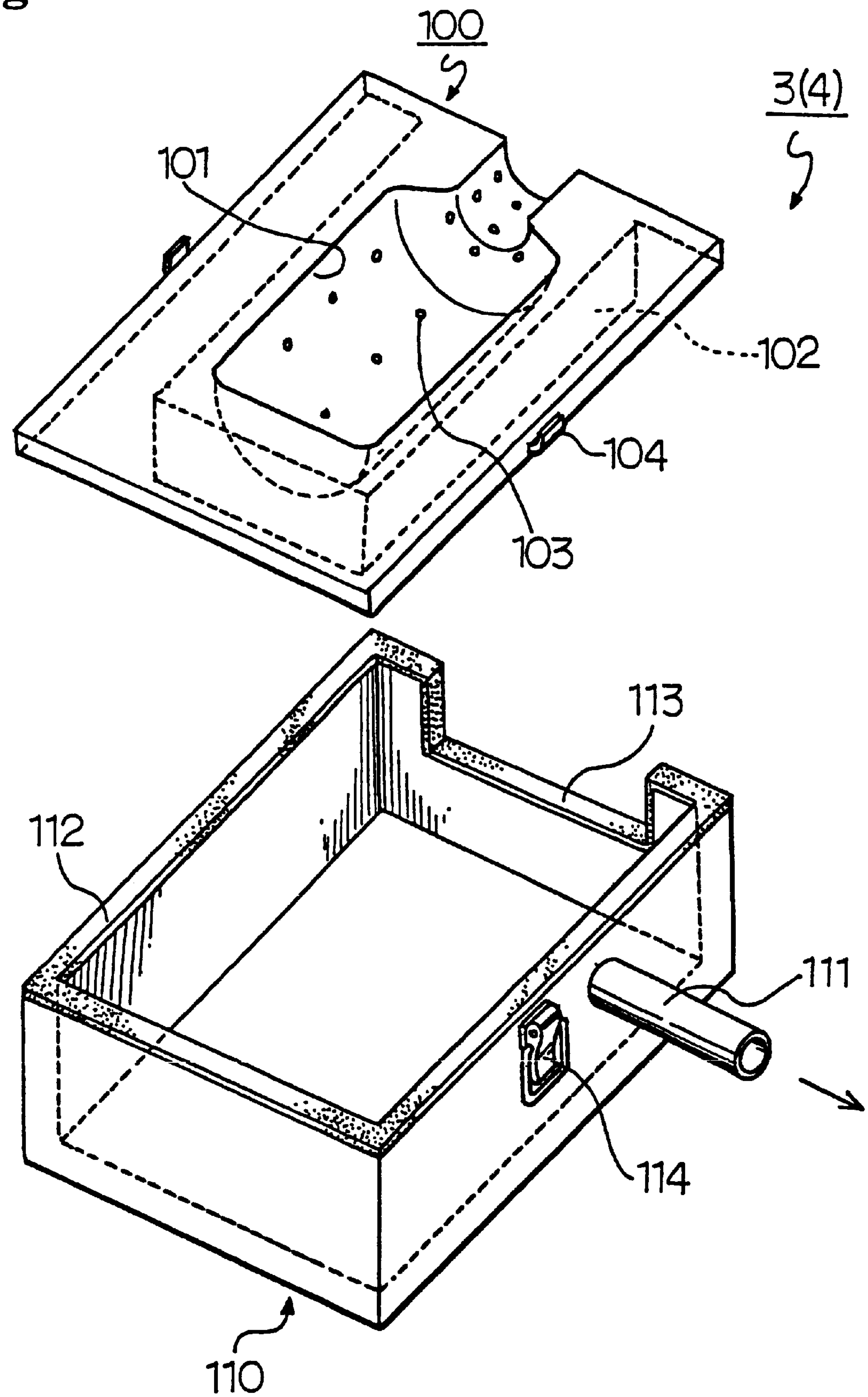

Fig.3

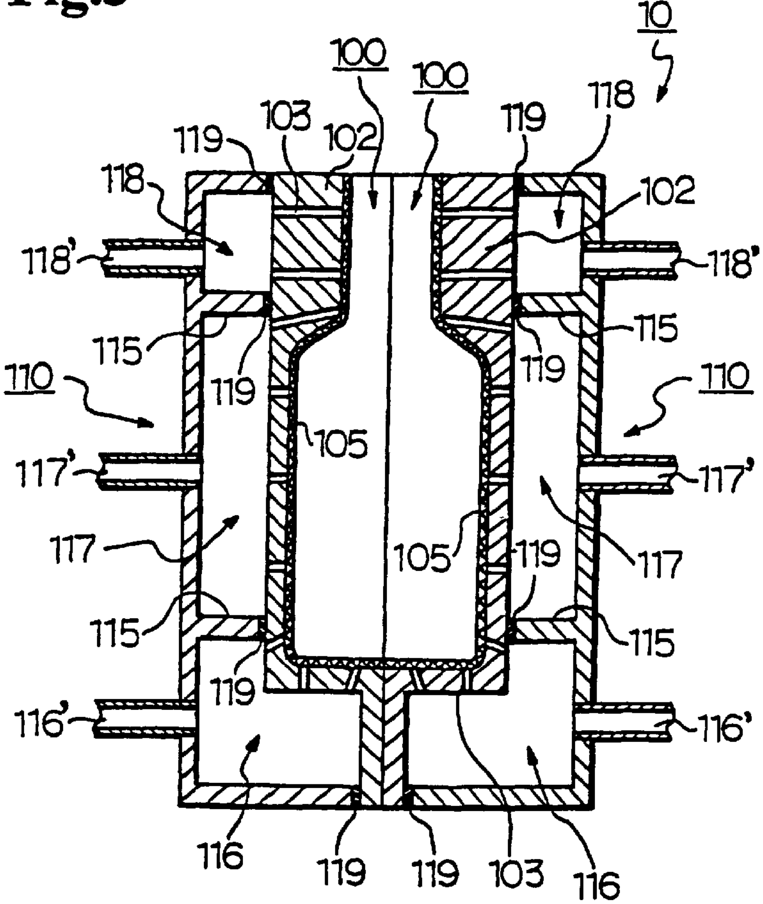
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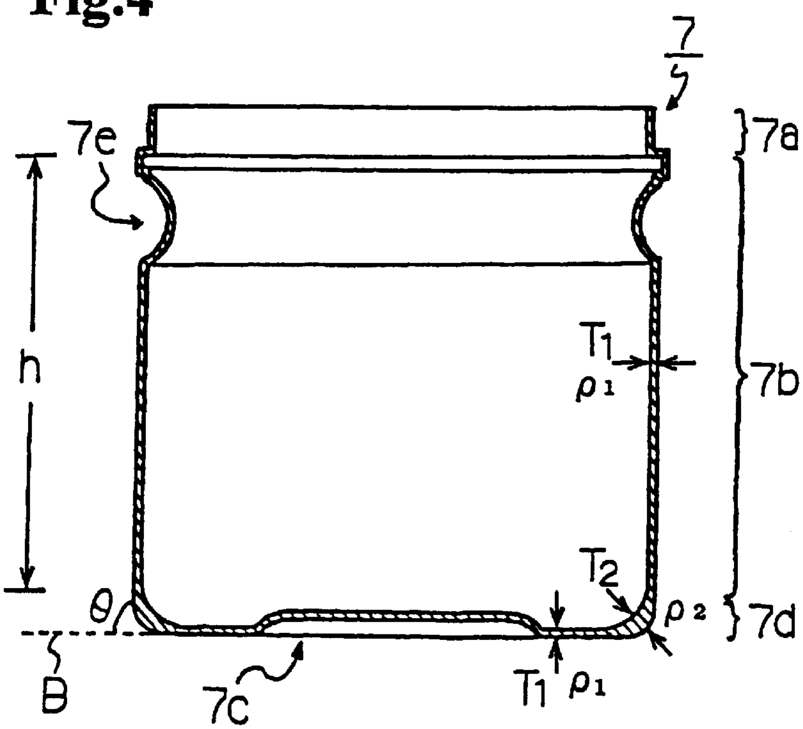
Fig.4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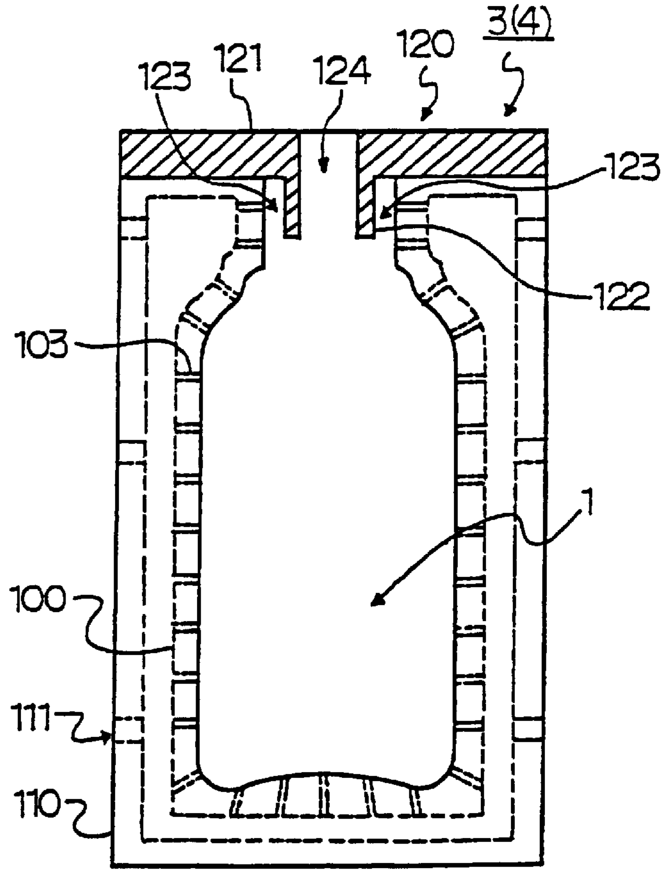
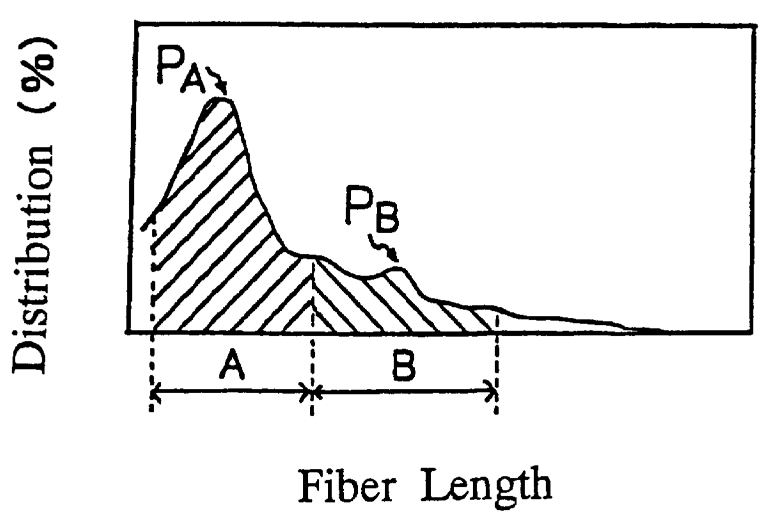
7b
T2
θ
ρ2
7d
B
7c
T1
ρ1

Fig.5



3(4)
120
124
121
123
123
122
103
1
100
111
110

Fig.6



Distribution (%)
P_A
P_B
A
B
Fiber Length

Fig.7 (a)

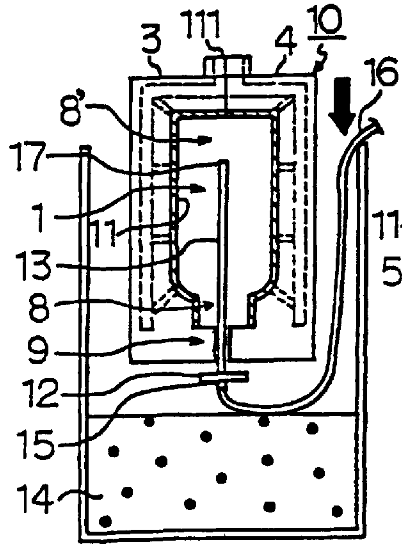


Fig.7 (b)

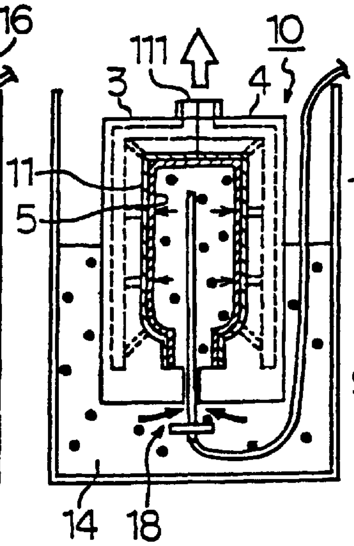


Fig.7 (c)

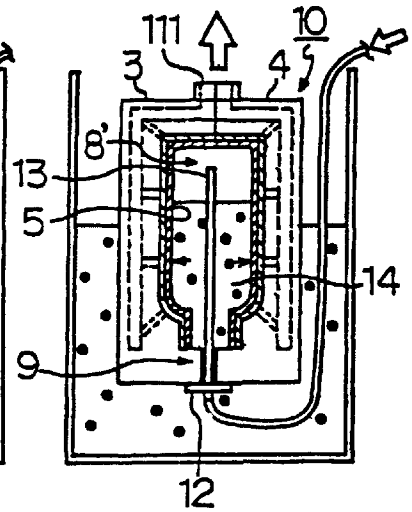


Fig.7 (d)

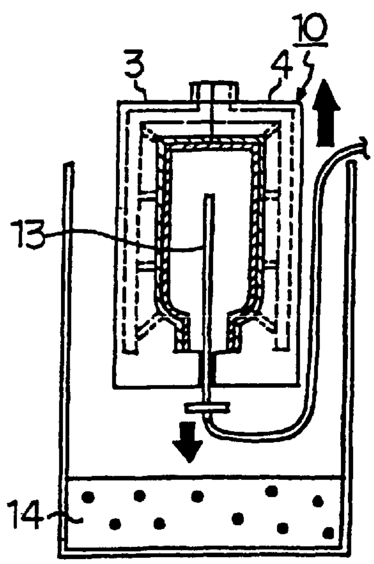


Fig.7 (e)

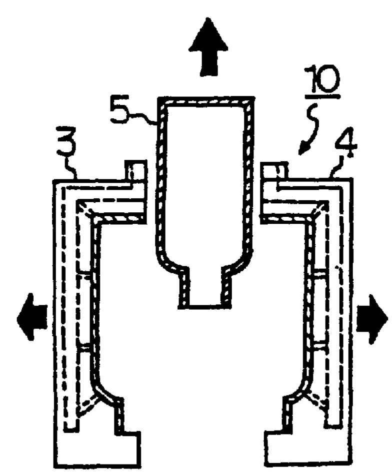


Fig.8

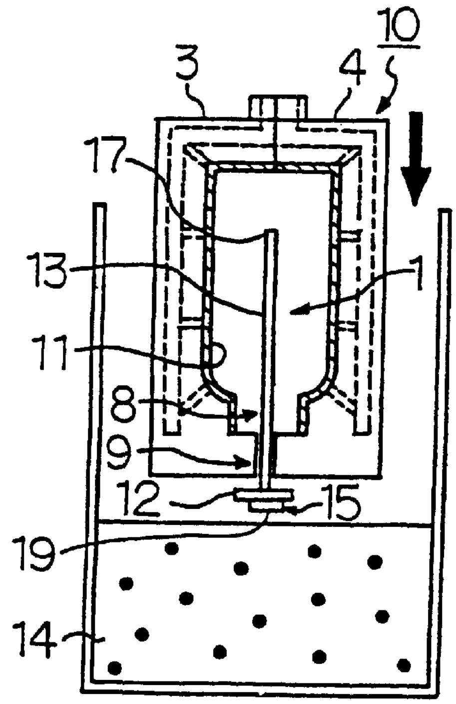


Fig.9 (a) **Fig.9 (b)** **Fig.9 (c)**

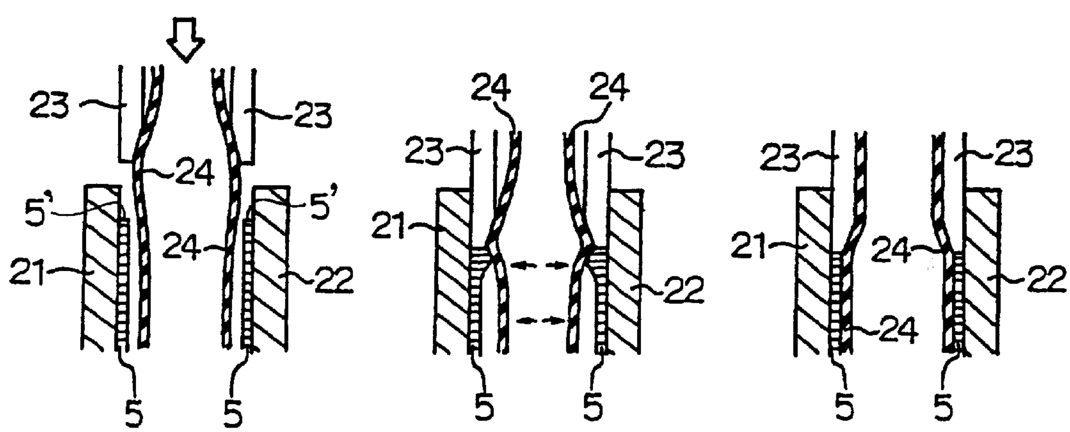


Fig.10

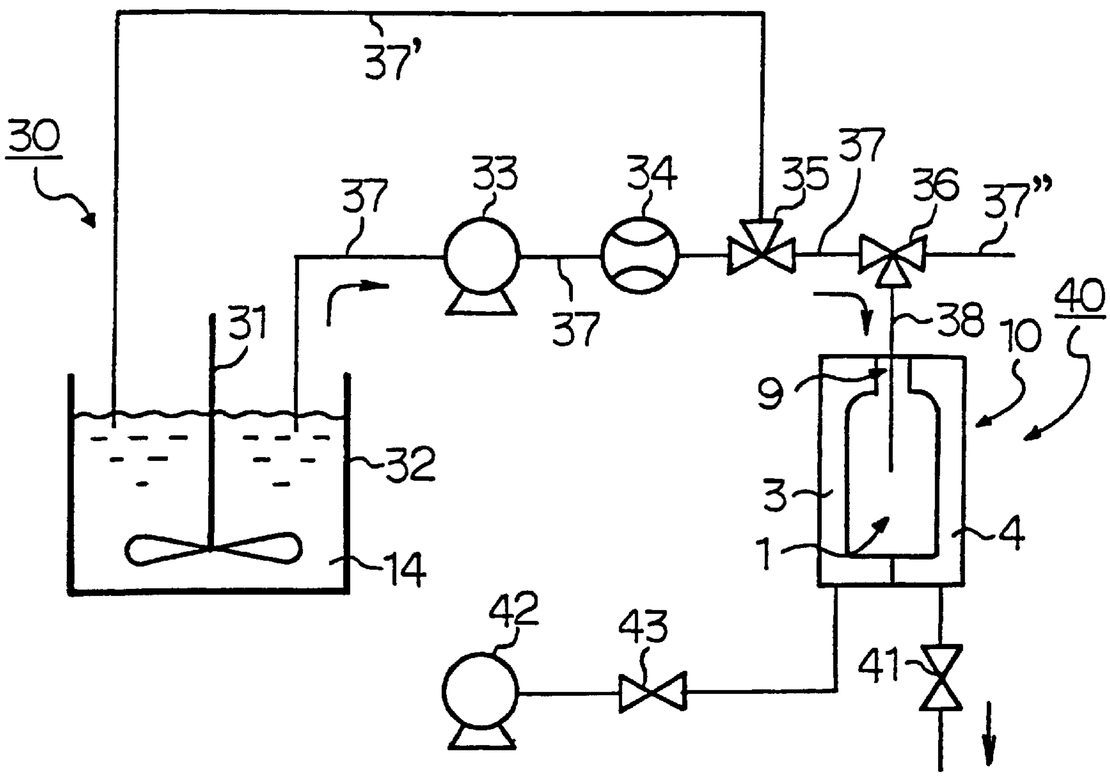


Fig.11 (a)

Fig.11 (b)

Fig.11 (c)

Fig.11 (d)

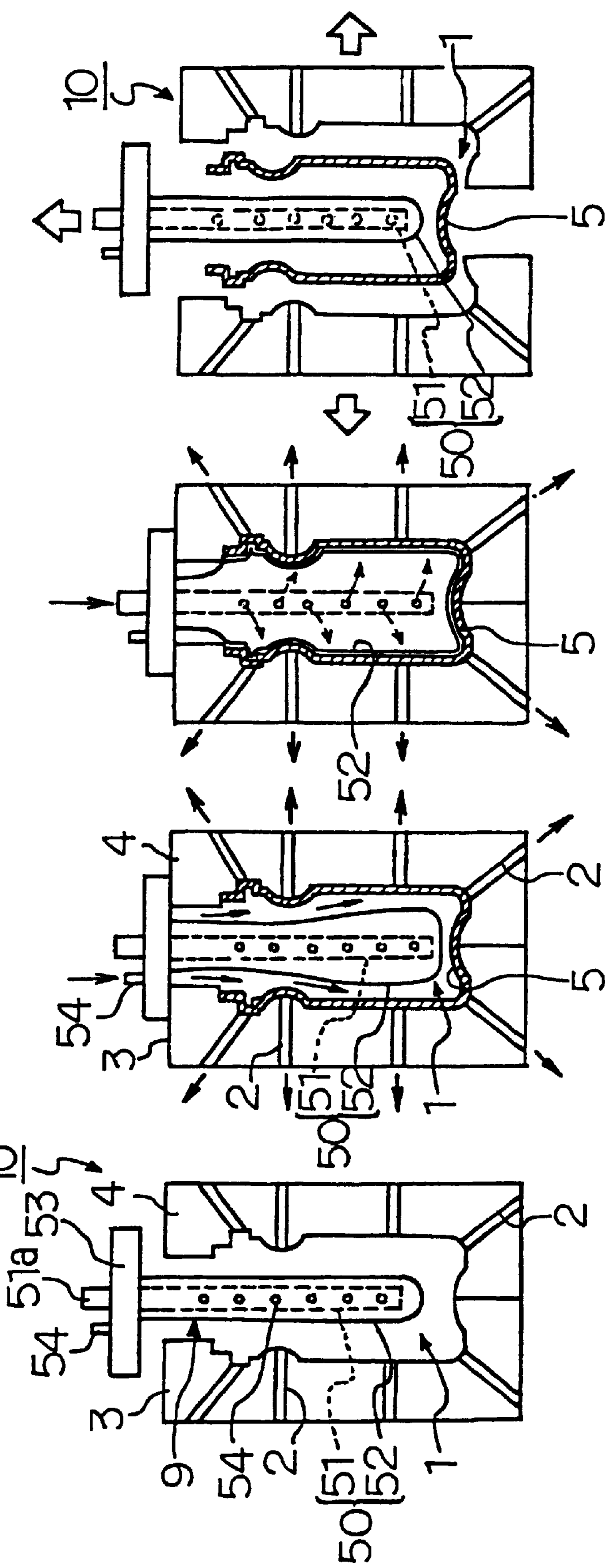


Fig.12

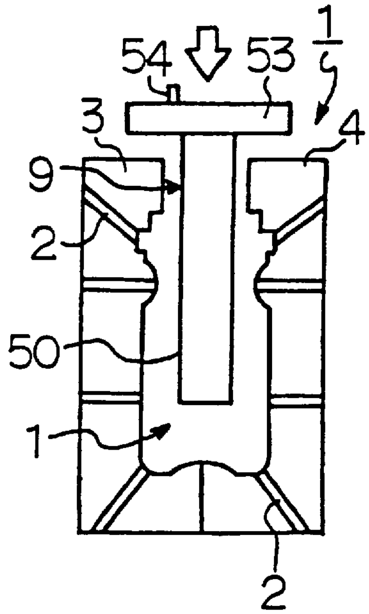


Fig.13 (a) Fig.13 (b) Fig.13 (c)

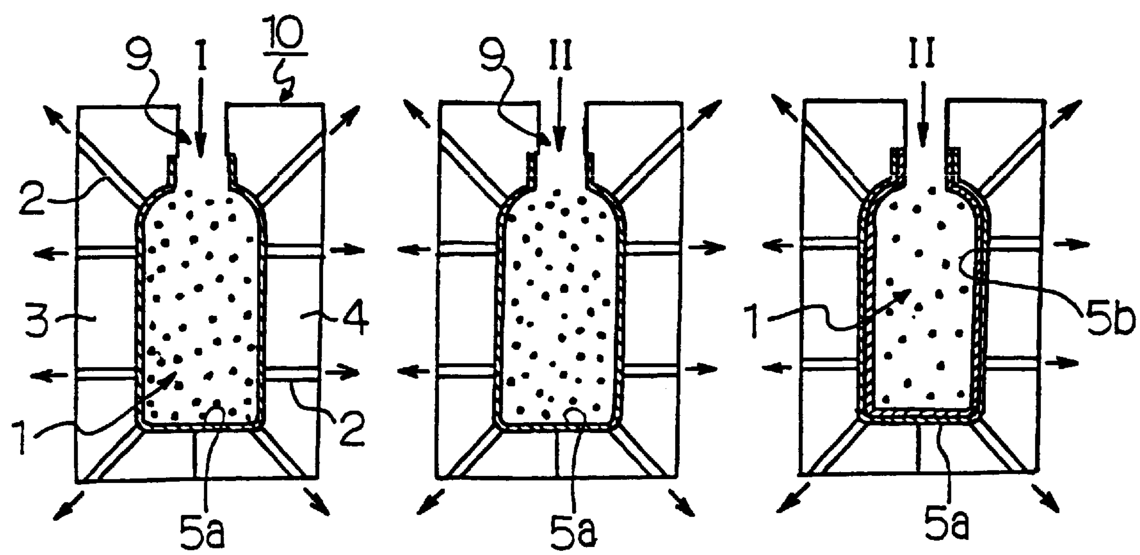


Fig.14

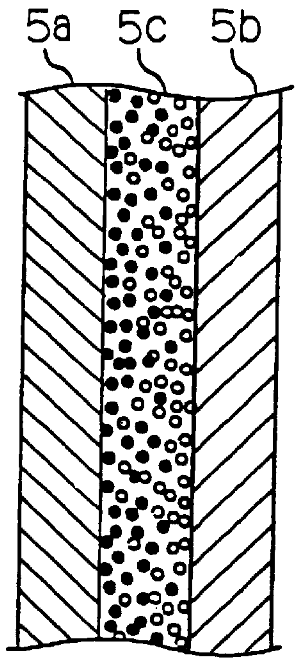
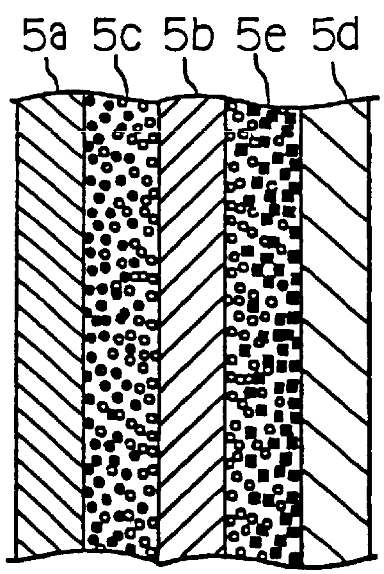


Fig.15



PULP MOLDED ARTICLE

This application is a Division of application Ser. No. 09/622,043 filed on Oct. 10, 2000, pending which was originally filed as International Application Number PCT/JP99/00775 on Feb. 22, 1999.

TECHNICAL FIELD

The present invention relates to a method for producing pulp molded articles that can be used as, for example, packaging members such as containers and cushioning materials.

BACKGROUND ART

Plastics are used as general materials of packaging containers, for example, those with a lid and bottles, for their excellent molding properties and productivity. However, because plastic containers involve various problems associated with waste disposal, pulp molded containers formed by pulp molding have been attracting attention as substitutes for plastic containers. Pulp molded containers are not only easy to dispose of but economically excellent because they can be manufactured by using recycled paper.

The following process is known as one of the methods for producing the pulp molded containers. A pulp slurry is poured into a split mold, for example, a pair of splits, which has a plurality of holes interconnecting the outside of the mold to the cavity and which is lined with a metal net, and the split mold is evacuated from the outside to deposit pulp fiber on the metal net thereby to form a pulp deposited body. After the pulp deposited body is shaped in conformity to the configuration of the split mold cavity, a pulp molded container made of the thus shaped pulp deposited body is removed from the mold and dried.

In the above process, however, the pulp deposited body should be taken out while having a considerably high water content, or the pulp deposited body needs a long time for dehydration and drying. Therefore, the pulp molded container is liable to deformation, and productivity is low due to poor drying efficiency. As a result, the pulp molded container is uncompetitive in price.

Japanese Patent Application Laid-Open No. 133972/9 discloses a process for producing a pulp molded container which comprises ejecting a pulp slurry from a special nozzle into a net mold, blowing high-pressure air to remove a considerable part of the water content, followed by removal from the mold and drying with hot air, infrared rays, etc.

However, having no step of bringing the pulp deposited body into intimate contact with the mold surface (pressing onto the mold surface), the above process fails to make a complicated shape and involves great variations of precision in product shape and dimension. Moreover, the drying efficiency is poor, and the product wall thickness (basis weight or density) is uncontrollable.

Accordingly, an object of the present invention is to provide a method for producing a pulp molded article by which a pulp molded article of complicated shape can be obtained by integral molding with no seams at the mouth portion, the body, and the bottom portion.

DISCLOSURE OF THE INVENTION

The present invention has achieved the above object by providing a method for producing a pulp molded article comprising the steps of supplying a pulp slurry into the cavity of a mold composed of a set of splits, the set of splits

being assembled together to form the cavity with a prescribed configuration, to form a pulp deposited body, feeding a fluid into the cavity to press the pulp deposited body onto the inner wall of the cavity thereby to dewater the deposited body,

said pulp slurry containing pulp fibers having an average fiber length of 0.8 to 2.0 mm, a Canadian Standard Freeness of 100 to 600 cc, and such a frequency distribution of fiber length as comprises 20 to 90%, based on the total fiber, of fibers whose length ranges longer than 1.4 mm and not longer than 3.0 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**(*a*), FIG. **1**(*b*), FIG. **1**(*c*), FIG. **1**(*d*) and FIG. **1**(*e*) schematically show a first embodiment of the present invention, wherein FIG. **1**(*a*) is the step of papermaking, FIG. **1**(*b*) is the step of inserting a pressing member, FIG. **1**(*c*) is the step of pressing, dewatering, and drying, FIG. **1**(*d*) is the step of opening the mold, and FIG. **1**(*e*) is the step of removing a pulp molded article.

FIG. **2** is a perspective exploded view of a split which is preferably used in the present invention.

FIG. **3** is a cross sectional view of another split mold which is preferably used in the present invention.

FIG. **4** is a vertical cross section showing an example of pulp molded articles produced according to the present invention.

FIG. **5** is a cross sectional view of still another split preferably used in the present invention.

FIG. **6** is a frequency distribution curve of fiber length of pulp fibers preferably used n the present invention.

FIG. **7**(*a*), FIG. **7**(*b*), FIG. **7**(*c*), FIG. **7**(*d*) and FIG. **7**(*e*) schematically show a third embodiment of the present invention, wherein FIG. **7**(*a*) is the step of inserting an air feed pipe into a mold and immersing the mold, FIG. **7**(*b*) is the step of sucking up a pulp slurry to form a paper layer, FIG. **7**(*c*) is the step of feeding air into the cavity and dewatering the pulp deposited body, FIG. **7**(*d*) is the step of pulling up the mold and drawing out the air feed pipe, and FIG. **7**(*e*) is the step of opening the mold to take out the pulp deposited body.

FIG. **8** schematically illustrates the step of inserting an air feed pipe into a mold and immersing the mold in a fourth embodiment of the present invention (corresponding to FIG. **7**(*a*)).

FIG. **9**(*a*), FIG. **9**(*b*) and FIG. **9**(*c*) schematically show a sixth embodiment of the present invention, wherein FIG. **9**(*a*) is the step of inserting an edge finishing member, FIG. **9**(*b*) is the step of making the opening portion of a pulp deposited body thicker, and FIG. **9**(*c*) is the step of pressing the pulp deposited body by a pressing member.

FIG. **10** schematically depicts a molding apparatus used in a seventh embodiment of the present invention.

FIG. **11**(*a*), FIG. **11**(*b*), FIG. **11**(*c*) and FIG. **11**(*d*) schematically show an eighth embodiment of the present invention, wherein FIG. **11**(*a*) is the step of inserting an insert member, FIG. **11**(*b*) is the step of preliminarily expanding a covering member, FIG. **11**(*c*) is the step of pressure dewatering a pulp deposited body, and FIG. **11**(*d*) is the step of opening the mold and taking out the pulp deposited body.

FIG. **12** schematically shows the step of inserting an insert member in a ninth embodiment of the present invention (corresponding to FIG. **11**(*a*)).

FIG. **13**(*a*), FIG. **13**(*b*) and FIG. **13**(*c*) illustrate a tenth embodiment of the present invention, wherein FIG. **13**(*a*) is

the step of injecting a first pulp slurry under pressure, FIG. **13**(*b*) is the step of injecting a second pulp slurry under pressure, and FIG. **3**(*c*) is the step of pressure dewatering.

FIG. **14** is a schematic view showing the multilayered structure of a pulp molded article obtained in the tenth embodiment.

FIG. **15** is a schematic view showing the multilayered structure of another pulp molded article obtained in the 10th embodiment (corresponding to FIG. **14**).

BEST MODE FOR CARRYING OUT THE INVENTION

Specific embodiments in the practice of the present invention are described below in detail by referring to drawings. To begin with, a first embodiment is described with reference to FIG. **1**.

The method for producing a pulp molded article according to this embodiment is characterized by comprising injecting a pulp slurry into the cavity **1** of a mold **10** composed of a set of splits **3** and **4**, the set of splits being butted together to form a cavity of prescribed shape, evacuating the split mold **3** and **4** to deposit pulp fibers on the inner wall of the split mold **3** and **4** to form a pulp deposited body **5**, inserting an elastic and stretchable pressing member **6** inside the split mold **3** and **4**, feeding a fluid into the pressing member **6** to inflate the pressing member **6**, pressing the pulp deposited body **5** with the inflated pressing member **6** onto the inner wall of the split mold **3** and **4** thereby to press, dewater, and dry the pulp deposited body **5**, withdrawing the fluid from the pressing member **6**, and removing a pulp molded article **7** from the splits **3** and **4**. The splits **3** and **4** each have a plurality of interconnecting holes **2** which connect the outer side thereof and the cavity **1**.

The method of producing the pulp molded article according to this embodiment will further be described in the concrete with reference to FIG. **1**. As shown in FIG. **1**(*a*), a pulp slurry is injected into a split mold for papermaking made of a pair of splits **3** and **4** having a plurality of interconnecting holes **2** interconnecting the outer side of the splits **3** and **4** to the cavity **1**. The pulp slurry is a dispersion of pulp fiber in water. The pulp fiber is preferably wood pulp, such as soft wood pulp and hard wood pulp, or non-wood pulp, such as bamboo and straw. The pulp fibers preferably have a length of 0.1 to 10.0 mm and a thickness of 0.01 to 0.05 mm. A particularly preferred composition of the pulp slurry will be described later.

In this particular embodiment, a cylindrical bottle whose opening (mouth) has a smaller diameter than its body is produced by using splits **3** and **4** providing a cavity configuration in conformity to the contour of the bottle.

As shown in FIG. **1**(*a*), the split mold **3** and **4** is evacuated from the outside of the splits **3** and **4** to build up pulp fiber on the inner wall of the split mold. A pulp deposited body **5** built up of the pulp fiber is thus formed on the inner wall of the split mold.

Then, the elastic and stretchable pressing member **6** is inserted into the cavity **1** while evacuating the cavity **1** as shown in FIG. **1**(*b*). The pressing member **6** is used as inflated in the cavity like a balloon thereby to press the pulp deposited body **5** onto the inner wall of the split mold while dewatering thereby to transfer the inner configuration of the split mold to the pulp deposited body. It is therefore preferably made of urethane, fluorine or silicone rubber, elastomers, etc., which are excellent in tensile strength, impact resilience and stretchability. The pressing member **6** may be a hollow bag having no elasticity, in which case, too, the pressing member is inserted into the split mold **3** and **4** to press the pulp deposited body **5** onto the inner wall of the split mold whereby the inner configuration of the split mold can be transferred to the pulp deposited body **5**. The pressing member **6** of bag form is made of, for example, a synthetic resin film such as a polyethylene film or a polypropylene film, a synthetic resin film having aluminum or silica deposited, a synthetic resin film laminated with aluminum foil, paper, fabrics, and the like. The bag should be equal to or greater in size than the inner contour of the pulp deposited body **5**. It is possible that the pressing member is not taken out after pressing the pulp deposited body **5** and left there as a liner of the pulp deposited body.

As shown FIG. **1**(*c*), a fluid is fed into the pressing member **6** to inflate the pressing member **6**. The inflated pressing member **6** presses the pulp deposited body **5** to the inner wall of the split mold to dewater under pressure. While the pulp deposited body **5** is pressed onto the inner wall of the split mold by the inflated pressing member **6**, the configuration of the inner wall of the split mold is transferred thereto. Since the pulp deposited body **5** in the cavity **1** is pressed to the inner wall of the split mold in this manner, the inner side configuration of the split mold can be transferred to the pulp deposited body **5** with good precision however complicated the configuration may be. The above-described fluid includes compressed air, oil and other liquids. The pressure for fluid feed is preferably 9.8×10^3 Pa to 49.0×10^5 Pa. Under a pressure lower than 9.8×10^3Pa, the pressing member **6** may fail to press the pulp deposited body **5** to the inner wall of the split mold. Under a pressure exceeding 49.0×10^5 Pa, the pulp deposited body **5** may be collapsed by the pressing member **6**.

Being pressed in the split mold **3** and **4** which is in a heated state, the pulp deposited body **5** is pressed, dehydrated, and dried. Thereafter the fluid is withdrawn from the pressing member **6**, whereupon the pressing member **6** shrinks by its own elastic force as shown in FIG. **1**(*d*). The shrunken pressing member **6** is taken out of the split mold **3** and **4**, and the split mold **3** and **4** is opened to remove the pulp molded article **7**. It is preferred for the fluid be pressurized so as to shorten the time for feeding and discharging the fluid in and out of the pressing member **6**. It is also preferred for the fluid be heated so as to shorten the drying time.

The pulp molded article **7** thus produced is a cylindrical bottle whose opening portion **7***a* (neck) has a smaller diameter than the body **7***b*. The neck **7***a*, the body **7***b*, and the bottom **7***c* are integrally unified with no seams. Having no joint seams on the outer surface, the pulp molded article **7** obtained by the method of the present invention has an excellent outer appearance.

According to the above-described embodiment, since the pulp molded article **7** is taken out after completion of drying and dehydration, the drying efficiency is high, the productivity is excellent, and deformation of the container can be prevented. According to this embodiment, because the pressing onto the inner wall of the split mold is under control, it is possible to impart a complicated shape, there is no scatter of shape and dimensional precision, and the drying efficiency is good. Further, it is possible to control the thickness and the basis weight, which enables strength design in designing the pulp molded article **7**. Furthermore, this embodiment provides a container having beautiful appearance on both the outer and inner sides thereof with satisfactory surface properties.

The above-described embodiment provides molded articles having complicated shapes, including, for example,

not only containers having a large height (60 mm or more) and those having no draft but those formed of three-dimensional curved surfaces, those with or without a bottom, and the like. Molded articles that can be produced include a bottomless hollow container that is straight (no draft angle) and as high as 60 mm or more, a bottomless hollow container having a dent in its middle with a three-dimensional curve, and a bottomless hollow container having a plurality of projections on the outer side around the lower edge thereof with a three-dimensional curve. Also included are a closed-end hollow container which is straight with no draft angle and whose opening is substantially equal to the bottom in diameter and a closed-end hollow container like a mortar whose opening has a larger diameter than the bottom. Additionally included are a closed-end or bottomless container whose opening has a smaller diameter than the body, a closed-end cylindrical hollow container having a relief pattern on its surface, a closed-end hollow container having a dent in the middle, a closed-end hollow container whose outer diameter gradually decreases from the opening to the bottom, and a closed-end hollow container whose outer diameter gradually increased from the opening toward the bottom.

While in the above-described embodiment pressure dewatering and heat drying of the pulp deposited body **5** are carried out in the same mold, these operations may be conducted in separate molds. In detail, after a pulp deposited body **5** is formed as shown in FIG. **1**(*a*), a pressing member **6** is inserted into the cavity **1** as shown in FIG. **1**(*b*). A pressurizing fluid is fed into the pressing member **6** whereby the pulp deposited body **5** is pressed onto the inner wall of the cavity **1** and dewatered under pressure. The mold **10** used here is not heated. On dewatering the pulp deposited body **5** to a predetermined water content, the split mold **3** and **4** is opened to take out a wet pulp preform. The pulp preform is set in a separately prepared heating mold (not shown) which is composed of a set of splits and heated to a predetermined temperature, where the preform is dried under heat. The heat drying can be accelerated by inserting a pressing member similar to the pressing member **6** used in the above-mentioned pressure dewatering into the cavity of the heating mold and feeding a pressurizing fluid into the pressing member to inflate the pressing member thereby pressing the wet preform onto the inner wall of the heating mold cavity.

In carrying out pressure dewatering and heat drying in separate molds, the cavity configuration of the mold for pressure dewatering is not particularly limited as long as the cavity configuration of the heated mold for heat drying is in conformity to the outer contour of a molded article to be made.

In the embodiment depicted in FIGS. **1**(*a*) through (*e*) the pressing member **6** which is elastic and stretchable may be replaced with a previously molded closed-end parison (preformed parison) comprising a thermoplastic resin in a heated state to a predetermined temperature.

In some detail, the above-mentioned parison is a previously molded cold parison of a thermoplastic resin, which has a screw thread around its neck. The thermoplastic resins preferably include polyethylene, polypropylene, and polyethylene terephthalate. A preferred parison heating temperature is 120 to 140° C. in case of using polypropylene or 100 to 130° C. in case of using polyethylene terephthalate.

A parison heated to a predetermined temperature is inserted into the cavity in place of the pressing member **6** shown in FIG. **1**(*b*). Subsequently, a pressurizing fluid is fed into the parison to inflate it, and the pulp deposited body is pressed onto the inner sides of the split mold by the inflated parison whereby the pulp deposited body is pressure dewatered and heat dried. Thus, the thermoplastic resin film is formed in intimate contact with the inner surface of the pulp deposited body **5** simultaneously with the shaping, dewatering, and drying of the pulp deposited body **5**. According to this method, since lining with the thermoplastic resin film can be performed simultaneously with the dewatering and drying of the pulp deposited body, the production process can be simplified to bring about improvement in productivity and reduction in cost. Having the thermoplastic resin film as a liner, the pulp molded article **7** produced by this method is excellent in waterproofness, moisture proofness, and gas barrier properties and enjoys a broadened range of application as a container.

FIG. **2** illustrates a split that can be used preferably in the above-described embodiment. This split is constructed of a papermaking part **100** having a cavity **101** to form a pulp deposited body and a manifold part **110** having a vacuum port **111** connecting with the outside. The manifold part **110** is fitted to the back of the cavity **101** to form a hollow chamber, surrounded by the back of the papermaking part **100** and the side walls **112** and the side wall **113** around the opening of the manifold part **110**. The block **102** of the papermaking part **100**, in which the cavity **101** is engraved, has a plurality of interconnecting holes **103** connecting the cavity **101** to the hollow chamber.

The papermaking part **100** and the manifold part **110** can be exchangeable clamped together by fastening a ring **114** of the manifold part **110** to a hook **104** of the papermaking part **100**. The papermaking part **100** varies according to the shape of the pulp molded article, only the papermaking part is changed in changing the kind of the product A sealant is provided on the upper edge of the side walls **112** of the manifold part **110** to prevent reduction of efficiency in evacuating the hollow chamber while the papermaking part **100** and the manifold part **110** are clamped together.

The splits shown in FIG. **3** are also preferred as a modification of the split shown in FIG. **2**. The manifold part **110** of the split shown in FIG. **3** has partitioning walls **115** and **115**. These partitioning walls divide the hollow chamber into three hollow sub-chambers (a first chamber **116**, a second chamber **117**, and a third chamber **118**), each of which is connected to the cavity through a plurality of interconnecting holes **103**. A sealant **119** is provided on the upper edge of each partitioning wall **115** (i.e., the edge in contact with the block **102** of the papermaking part **100**). The chambers **116**, **117** and **118** have the respective vacuum ports (a first vacuum port **116**', a second vacuum port **117**, and a third vacuum port **118**', respectively) connected to an external suction means. These vacuum ports can be controlled independently. A net layer **105** hereinafter described is disposed on the cavity **101** of the papermaking part **100**.

In molding a pulp molded article by use of the splits shown in FIG. **3**, the suction pressure of each of the chambers **116**, **117**, and **118** can be controlled so as to vary the suction force applied from each hollow chamber to the respective parts of the surface of the cavity **101** through the respective interconnecting holes. Through such suction control, a desired part of the pulp molded article that particularly requires strength can be made thicker. For example, where the suction pressure of only the first hollow chamber is increased, the amount-of pulp fiber deposited on the corresponding part of the cavity **101** which connects with the first hollow chamber can be made larger than that

on the other parts of the cavity connecting with the other hollow chambers. It is possible, as a result, to produce a pulp molded article having that part of the wall made thicker.

It is possible to control the wall thickness of the pulp molded article more precisely by providing time lags among the hollow chambers in starting or stopping suction. For example, a pressure gauge (vacuum gauge) is set at each vacuum port, and the hollow chambers **116, 117**, and **118** are independently operated under the respective pressures. When the degree of vacuum decreases to a certain set level as pulp fiber is accumulated on the cavity **101**, the suction of each of the hollow chambers **116, 117**, and **118** is ceased. As a result, waste of suction energy can be avoided.

Suction control failures due to breakage of the net layer **105**, clogging of the interconnecting holes **103**, a trouble of a suction means, etc. can be monitored by checking the pressure gauge provided for each hollow chamber.

By the use of the split molds shown in FIGS. **2** and **3** pulp molded articles of various shapes can be obtained by exchanging the papermaking part **100**. For example, a carton shown in FIG. **4** can be produced in place of the cylindrical bottle shown in FIG. **1**(*d*).

The pulp molded article **7** shown in FIG. **4** has an opening portion (neck) **7***a* in the upper portion, a body **7***b*, and a bottom **7***c*. The body **7***b* and the bottom **7***c* connect via a curved portion **7***d* to give the molded article **7** increased impact strength. The horizontal cross section of the molded article **7** is almost equal in the height direction and is a rectangle with its four corners rounded to give the molded article **7** increased impact strength and with its four sides gently curved outward. The body **7***b* has a continuous recess **7***e* around its circumference to make the molded body **1** easier to hold.

When the molded article **7** is seen from its side, the outer surfaces (exclusive of the recess **7***e*) of the front and rear walls forming the body **7***b* are straight in the direction of height. Similarly when the molded article **7** is seen from the front, the outer surfaces (exclusive of the recess **7***e*) of the left and right side walls forming the body **7***b* are straight in the direction of height.

In the molded article **7**, the angle θ between the plane of contact B of the bottom **7***c* and the outer side wall of the body **7***b* is more than 85°, preferably 89° or more (about 90° in FIG. **4**) with respect to any wall of the front and rear side walls and the left and right side walls, and the height h (see FIG. **4**) of the body **7***b* is 50 mm or more, preferably 100 mm or more. The angle θ can exceed 90°. Conventional methods of producing pulp molded articles have encountered various restrictions in designing containers, and it has been practically impossible to produce a molded article with such a large rising angle of the side walls and a considerable depth. The method according to the present invention is freed of such inconvenience.

It is preferred for the molded article **7** to have a larger thickness at the corners in its vertical cross section and/or horizontal cross section than the other portion to improve the compressive strength (buckling strength) of the molded article **7** as a whole over the one having equal thickness in these portions. For example, in the vertical cross section of the molded article **7** shown in FIG. **4**, the thickness T**2** of the corners, i.e., curved bends **7***d*, is preferably greater than the thickness T**1** of the body **7***b* (i.e., T**2**>T**1**). In this case, where T**2**/T**1** is 1.5 to 2, the improvement on compressive strength of the whole molded article **7** can be secured. It is preferred that the thickness T**1** be 0.1 mm or greater for the molded article **7** to exhibit the minimum compressive strength required. It is required for the molded article **7** to have a prescribed compressive strength, considering that the molded articles **7** are to be transported or stacked up in a warehouse or a shop. It is similarly preferred that the molded article **7** has a larger thickness at the corners (T**2**) in its horizontal cross section (not shown) than the thickness T**1** in the other portions.

In cases where the corners of the molded article **7** in the vertical cross section and/or the horizontal cross section satisfy the relationship that their density (ρ**2**) is smaller than the density (ρ**1**) of the other portions (i.e., ρ**1**>ρ**2**) as well as the above-described relationship between T**1** and T**2**, there is produced an effect that two conflicting phenomena—an improvement in compressive strength of the molded article **7** and a reduction in amount of the material used—can result. This effect is more notable when 0.1×ρ**1**<ρ**2**<ρ**1**. The molded article **7** which satisfies these relationships has a compressive strength of 190 N or greater. The compressive strength as referred to here is the maximum strength in compressing the molded article **7** along the direction of height at a speed of 20 mm/min. The above-described relationship between T**1** and T**2** and between ρ**1** and ρ**2** can be established by, for instance, properly selecting the pressure or the amount of flow of the pressurizing fluid used in pressing with the pressing member **6**, the material or shape of the pressing member **6**, the shape of the molded article, and the like in carrying out the aforementioned method.

As stated above, it is easy with the split mold shown in FIG. **3** to make a desired part of a pulp molded article thicker. As an alternative, it is also easy with the split mold shown in FIG. **5** to make a desired part of a pulp molded article thicker.

The split mold shown in FIG. **5** has a papermaking part **100**, a manifold part **110**, and a mold **120** for creating slurry stagnation (hereinafter "a stagnation-causing mold"). The stagnation-causing mold **120** is inserted into the cavity, which is formed by closing the split molds, to form a space with the inner wall of the cavity in which space the slurry stagnates. The papermaking part **100** and the manifold part **110** have the same structures as shown in FIG. **3**.

On butting the splits shown in FIG. **5** to each other, there is formed inside a cavity in conformity to the contour of an article to be molded. The part of the cavity that corresponds to the opening portion of the molded article (this part is referred to as "the part of the cavity corresponding to the opening portion" in this embodiment) has an opening open to the outside. Into this part is inserted a wall **122** for making the slurry stagnant (hereinafter "a slurry stagnation wall", described later) of the stagnation-causing mold **120**. While not depicted, the inner side of the part of the cavity corresponding to the opening portion has grooves corresponding to the screw thread.

As shown in FIG. **5**, the stagnation-causing mold **120** is composed of a rectangular top plate **121** and a cylindrical slurry stagnation wall **122** hanging from approximately the center portion of the lower side of the top plate **121**. The slurry stagnation wall **122** forms a hollow cylinder which vertically pierces the stagnation-causing mold **120** and serves as a gate **123** through which a pulp slurry is poured in. The slurry stagnation wall **122** of the stagnation-causing mold **120** is inserted into the part of the cavity corresponding to the opening portion, and the lower side of the top plate **121** and the end of the manifold part **110** are brought into contact to complete the split mold **10**.

The outer diameter of the slurry stagnation wall **122** is smaller than the cavity diameter of the part of the cavity

corresponding to the opening portion. Therefore, an annular space **123** in which the slurry stagnates is formed between the inner wall of that part of the cavity corresponding to the opening portion and the outer side of the slurry stagnation wall **122** inserted in that part of the cavity corresponding to the opening portion.

Where the molding is carried out by use of the above-described split mold, the pulp slurry goes around to fill the annular space **123** formed between the outer side of the slurry stagnation wall **122** and the inner side of the part of the cavity corresponding to the opening portion and tends to stay there, making the pulp fiber be accumulated there more than on the other parts of the cavity **1**. It follows that a pulp deposited body formed on the inner wall of the cavity **1** has a thicker wall in its portion corresponding to the vicinity of the upper edge of the opening portion of a molded article than in the other portions. The thickness of the thicker portion is proportional to the breadth of the annular space **124**.

The pulp molded article thus obtained has a thick-walled portion around its neck from its upper edge to a prescribed depth which is thicker than the body and the bottom. The thick-walled portion is continuous along the circumference of the neck. A screw to thread mating a cap is provided on the outer side of the neck. The contour of the vertical cross section of the screw thread can be triangular or rectangular in accordance with the strength of the neck or the productivity of the molded article (e.g., easiness with which the screw thread is dried or easiness with which the shape is transferred). Where the molded article is to be capped and uncapped frequently, the screw thread preferably has a trapezoidal contour. In order to increase the durability against capping and uncapping, the neck including the screw thread may be coated or impregnated with a resin to increase the strength.

The pulp slurry which can be used in the above-described embodiment preferably contains pulp fibers having an average fiber length of 0.8 to 2.0 mm, a Canadian Standard Freeness of 100 to 600 cc, and such a frequency distribution of fiber length as comprises 20 to 90%, based on the total fiber, of fibers whose length ranges from 0.4 mm to 1.4 mm and 5 to 50%, based on the total fiber, of fibers whose length is longer than 1.4 mm and not longer than 3.0 mm. Pulp molded articles obtained from such a pulp slurry are uniform in thickness, free from cracks in papermaking, and excellent in surface smoothness.

It is preferred for the pulp fibers to have an average length of 0.8 to 2.0 mm, particularly 0.9 to 1.8 mm, especially 1.0 to 1.5 mm. If the average fiber length is less than 0.8 mm, cracks tend to develop on the surface of the molded article during papermaking or drying, or the molded article tends to have poor mechanical properties such as impact strength. If the average fiber length exceeds 2.0 mm, the pulp deposited body formed by papermaking tends to have unevenness of thickness only to provide a molded article with poor surface smoothness. The term "average fiber length" as used herein is a value obtained by measuring the frequency distribution of pulp fiber length and calculating a length-weighted fiber length from the distribution.

It is preferred for the pulp fibers to have a freeness of 100 to 600 cc, particularly 200 to 500 cc, especially 300 to 400 cc. A freeness less than 100 cc is so low that speed-up of the molding cycle tends to be difficult, and dewatering of the molded article tends to be insufficient. A freeness exceeding 600 cc is so high that the pulp deposited body formed by papermaking tends to suffer from unevenness of thickness.

It is preferred for the pulp fibers to have such a fiber length frequency distribution as comprises 20 to 90%, based on the total fiber, of fibers whose length is within a range of from 0.4 mm to 1.4 mm (hereinafter referred to as range A) and 5 to 50%, based on the total fiber, of fibers whose length is longer than 1.4 mm and not longer than 3.0 mm (hereinafter referred to as range B). FIG. **6** furnishes an example of fiber length frequency distribution curves of pulp fibers preferably used in the method of the present invention. The ratio of the area in range A (indicated with slant lines) to the total area in the frequency distribution curve is equivalent to the proportion (%) of the pulp fibers whose length falls within range A. Similarly, the ratio of the area in range B (indicated with slant lines) to the total area in the frequency distribution curve is equivalent to the proportion (%) of the pulp fibers whose length falls within range B. By using pulp fibers having such a frequency distribution as well as an average fiber length and a freeness falling within the above respective ranges, pulp molded articles uniform in thickness, free from crack development during papermaking, and excellent in surface smoothness can be obtained. It is still preferred that the proportion of the pulp fibers having a fiber length within range A be 30 to 80%, particularly 35 to 65% and that the proportion of the pulp fibers having a fiber length within range B be 7.5 to 40%, particularly 10 to 35%.

To further enhance the above-described effects, it is particularly preferred for the pulp fibers to have such a frequency distribution as has peaks P_A and P_B in ranges A and B, respectively, as represented by FIG. **6**.

Pulp fibers having the aforesaid average fiber length, freeness and fiber length frequency distribution can be obtained by selecting, for example, the kind of the fiber (from, e.g., NBKP, LBKP, used paper pulp, etc.), beating conditions, conditions of blending a plurality of pulp kinds, and the like. It is particularly preferred to prepare the above-described pulp fiber by blending relatively long pulp fibers having an average fiber length of 1.5 to 3.0 mm and relatively short pulp fibers having an average fiber length of 0.3 to 1.0 mm at a ratio of 90/10 to 40/60 (by weight) for obtaining a molded article having high surface smoothness.

The above-described pulp slurry can consist of the above-described pulp fiber and water. The pulp slurry can further contain other components, such as inorganic substances, e.g., talc and kaolinite; inorganic fiber, e.g., glass fiber and carbon fiber, synthetic resin powder or fiber, e.g., polyolefin; nonwood or plant fibers; polysaccharides; and the like. The amount of these components is preferably 1 to 70% by weight, particularly 5 to 50% by weight, based on the total amount of the pulp fibers and these components.

The second to tenth embodiments of the present invention are then described with reference to FIGS. **7** through **15**. Only the particulars different from the first embodiment will be explained. The description about the first embodiment appropriately applies to the particulars that are not explained here. The members in FIGS. **7** to **15** which are the same as those in FIGS. **1** to **6** are given the same numerical references as used in FIGS. **1** to **6**.

In the second embodiment, a net layer composed of a coarse mesh and a fine mesh is put on the surface of each of the splits **3** and **4** of the split mold for papermaking used in the first embodiment, and a pulp slurry is then injected to form a pulp deposited body. In detail, the net layer is composed of a first mesh and a second mesh that is finer than the first mesh. The first mesh is tightly put on the splits **3** and **4**, and the second mesh is put on the first mesh. Or, a net layer composed of a first mesh and a second mesh that is

finer than the first mesh is used, and the first mesh is tightly put on the splits **3** and **4**, and the second mesh is formed on the first mesh. With the fine second mesh put on the coarse first mesh, or with the fine second mesh formed on the coarse first mesh, the number of the interconnecting holes **2** to be bored in the splits **3** and **4** can be decreased, and a pulp deposited body **5** hereinafter described can be accumulated with a uniform thickness.

The first mesh and the second mesh make a coarse net layer and a fine net layer, respectively, and, when put on the splits **3** and **4**, are in tight contact with the surface contour of the splits **3** and **4**. Each of the first mesh and the second mesh is made of, for example, a natural material, a synthetic resin or a metal or a combination of two or more thereof. The net layers can be given a surface modifying coat to improve the slip properties, heat resistance, and durability. The natural materials include plant fibers and animal fibers. The synthetic resins include thermoplastic resins, thermosetting resins, recycled resins, and semi-synthetic resins.

The average maximum opening width of the first mesh is preferably 1 to 50 mm, particularly 5 to 10 mm. The term "opening width" of the first mesh means the distance between lines of the mesh. If the average maximum opening width is less than 1 mm, the evacuation efficiency is so poor that the pulp fibers are hardly deposited on the surface of the net layer, and a pulp deposited body is hardly formed. If it exceeds 50 mm, the second mesh may pass through between lines of the first mesh to come into contact with the surface of the paper mold. In this case, the evacuation efficiency is reduced in places, resulting in uneven thickness of the pulp deposited body.

The average opening area ratio of the first mesh is preferably 30 to 95%, particularly 75 to 90%. If the average opening area ratio is less than 30%, the evacuation efficiency is so poor that formation of a pulp deposited body is difficult. If it exceeds 95%, the second mesh may come into contact with the surface of the paper mold, which deteriorates the evacuation efficiency in places. As a result, the pulp deposited body will have an uneven thickness.

On the other hand, the average maximum opening width of the second mesh is preferably 0.05 to 1.0 mm, particularly 0.2 to 0.5 mm. The term "opening width" of the second mesh means the inner size between lines of the mesh. If the average maximum opening width is less than 0.05 mm, the evacuation efficiency is so poor that a pulp deposited body is hardly formed. If it exceeds 1.0 mm, the pulp fibers tend to pass therethrough, and it is difficult to form a pulp deposited body.

The average opening area ratio of the second mesh is preferably 30 to 90%, particularly 50 to 80%. If the average opening area ratio is less than 30%, the evacuation efficiency is so poor that a pulp deposited body is hardly formed. If it is more than 90%, the pulp fibers easily pass therethrough, tending to result in difficulty in forming a pulp deposited body.

In this particular embodiment, a net having an average maximum opening width of 3 to 6 mm, an average opening area ratio of 80 to 92%, and a line width of 0.3 mm in the state fitted on the splits **3** and **4** was used as the first mesh. Such a first mesh has an average maximum opening width of 0.08 to 0.25 mm, an average opening area ratio of 46%, and a line width of 0.12 mm in the state before being put on the splits **3** and **4**. As the second to mesh, a stocking having an average maximum opening width of 0.22 to 0.35 mm, an average opening area ratio of 58 to 69%, and a line width of 0.06 to 0.07 mm in the state fitted on the splits **3** and **4** was used. Such a second mesh has an average maximum opening width of 0.38 to 0.42 mm, an average opening area ratio of 75%, and a line width of 0.05 to 0.06 mm in the state before being put on the splits **3** and **4**. The second mesh does not need to have more rigidity than enough not to come into contact with the surface of the split mold through the openings of the first mesh when the inside of the split mold is evacuated.

In the third embodiment, the mold **10** shown in FIGS. **7**(*a*) through (*e*) is used. The mold **10** is of the type that a set of splits **3** and **4** are butted together to make a cavity **1** in conformity to the outer contour of an article to be molded which has a neck and also to make a slurry inlet gate **9** which connects the part of the cavity corresponding to the neck (the cavity part **8**) to the outside.

In the mold **10**, the slurry inlet gate **9**, which is formed by closing the two splits **3** and **4**, has a smaller horizontal cross section area than the cavity part **8** corresponding to the neck. This design has the following advantage. When a pulp slurry is made to flow into the cavity **1** by suction to form a layer of pulp fiber, the pulp fiber layer, especially the pulp fiber layer which will become the neck of a molded article, is effectively prevented from being disturbed by the flow of the slurry into the cavity **1** by suction, and the resulting molded article will have a uniform thickness at the neck.

While depending on the size or shape of the article to be molded, the degree of pulp slurry suction, and the like, the ratio of the cross section area of the slurry inlet gate **9** and that of the cavity part **8** corresponding to the neck is preferably 0.05 to 0.99, particularly 030 to 0.70, with which the wall thickness can be made uniform all over the molded article, and the papermaking efficiency is improved.

The method of producing a pulp molded article having a neck and a closed end (bottom) by use of the above-described mold **10** will be described by referring to FIG. **7**. As shown in FIG. **7**(*a*), a pair of splits **3** and **4** are butted to each other to make the mold **10** having a cavity **1** with a net layer **11** fitted on the inner side thereof. An air feed pipe **13** having a collar **12** is inserted into the cavity **1** through the slurry inlet gate **9**, and the mold **10** having the air feed pipe **13** inserted therein is immersed in a pulp slurry **14** with its slurry inlet gate **9** down. The air feed pipe **13** has a disc-shaped collar **12** near its end **15** to which an air feed hose **16** is connected. The collar **12** is larger than the section area of slurry inlet gate **9** of the mold **10**. The air feed hose **16** is connected to an air feed source (not shown). The air feed pipe **13** is inserted into the cavity **1**, led by its free end **17**. The length of the air feed pipe **13** from the free end **17** to the collar **12** is such that the free end **17** does not reach the part of the cavity **1** corresponding to the bottom (part **8**) when the collar **12** is brought into contact with the slurry inlet gate **9**.

As shown in FIG. **7**(*b*), the pulp slurry **14** is sucked in through a gap **18** between the slurry inlet gate **9** and the collar **12** of the air feed pipe **13** by a suction means (not shown) connected to a vacuum port **111**, whereby pulp fibers are built up on the net layer **11** along the inner wall of the cavity **1** to form a pulp deposited body **5** on the net layer **11**. The degree of suction, while dependent on the size and shape of the article to be molded, is usually −0.13 to −101.3 kPa for preference, particularly −13.3 to −90.0 kPa.

On forming a pulp deposited body **5** to a prescribed thickness, the slurry inlet gate **9** is blocked by the collar **12** of the air feed pipe **13** as shown in FIG. **7**(*c*) to stop the flow of the pulp slurry **14**. With the slurry inlet gate **9** blocked by the collar **12**, air is forced to be fed to the upper space of the

cavity **1** (i.e., the vicinity of the cavity part **8'** corresponding to the bottom) through the air feed pipe **13** by means of an air feed source (not shown) while evacuating the cavity **1**, whereby the pulp slurry **14** existing in the cavity **1** is discharged outside, and the pulp deposited body **5** is dewatered. Since the evacuation is carried out while feeding air to the upper space of the cavity **1** filled with the pulp slurry **14**, the deposited pulp fibers are effectively prevented from being disturbed by the evacuation to provide a molded article with uniform thickness. Since the cross section area of the slurry inlet gate **9** is smaller than that of the cavity part **8** corresponding to the neck, the pulp fibers accumulated on the cavity part **8** corresponding to the neck are effectively prevented from being disturbed by the flow of the pulp slurry **14** thereby to further secure the uniformity in thickness of the neck of the resulting molded article. From the standpoint of shape retention of the pulp deposited body **5** and productivity, it is preferred to conduct the above-described dewatering to such a degree as to reduce the water content of the pulp deposited body 5 to 10 to 95% by weight, particularly 40 to 80% by weight.

After dewatering the pulp deposited body **5** to a predetermined water content, the mold **10** is drawn from the pulp slurry **14** as shown in FIG. **7**(*d*), and the air feed pipe **13** in the mold **10** is pull down. Subsequently the mold **10** is opened, and the pulp deposited body **5** is taken out as shown in FIG. **7**(*e*). Since the pulp deposited body **5** has been dewatered to a degree enough to have sufficient shape retention by this time, there is no fear of shape deformation when it is taken out. The pulp deposited body **5** is then set in a heating mold heated to a prescribed temperature and heat dried to give a pulp molded article. The heat drying operation can be carried out in the same manner as in the first embodiment.

In the fourth embodiment, an air feed pipe **13** is used similarly to the third embodiment as shown in FIG. **8**. The air feed pipe **13** has a disc-shaped collar **12** near the end **15** similarly to the third embodiment but with no air feed hose connected to that end **15**. Instead, the end **15** is blocked by a blocking means **19** to prevent liquid from entering the air feed pipe **13**. The air feed pipe **13** is inserted into the cavity **1**, led by the other end **17**. The mold **10** having the air feed pipe **13** inside is immersed in the pulp slurry **14** with the slurry inlet gate **9** down.

The pulp slurry **14** is sucked in through a gap between the slurry inlet gate **9** and the collar **12** of the air feed pipe **13** while evacuating the cavity **1**, whereby pulp fibers are built up on the net layer **11** along the inner wall of the cavity **1** to form a pulp deposited body **5** on the net layer **11**.

On forming a pulp deposited body **5** to a prescribed thickness, the slurry inlet gate **9** is blocked by the collar **12** of the air feed pipe **13** to stop the flow of the pulp slurry **14**. The evacuation is once stopped simultaneously. The mold **10** with its gate **9** blocked by the collar **12** is drawn from the pulp slurry **14**. Subsequently, the blocking means **19** that has been blocking the end **15** of the air feed pipe **13** is removed to let air enter spontaneously through the air feed pipe **13** to the space near the cavity part **8'** corresponding to the bottom in the cavity **1** and, at the same time, evacuation is resumed, whereby the water of the pulp slurry **14** contained in the cavity **1** is discharged, and the pulp deposited body **5** is dewatered. In this manner the accumulated pulp fibers are effectively protected from being disturbed by the suction to provide a molded article with a uniform thickness similarly to the case of the third embodiment.

On dewatering the pulp deposited body **5** to a predetermined water content, the air feed pipe **13** inside the mold **10** is pulled down. Thereafter, the same operation as in the third embodiment is carried out to obtain a closed-end pulp molded article having a neck.

The fifth embodiment is practically the same as in the third and fourth embodiments, except that the air feed pipe is not used. In detail, the mold is immersed in a pulp slurry with its slurry inlet gate down. The pulp slurry is sucked up through the gate **9**, whereby pulp fibers are accumulated on the net layer provided on the inner wall of the cavity to form a pulp deposited body. On forming a pulp deposited body to a prescribed thickness, evacuation is once stopped, and the mold is pull up from the pulp slurry. The evacuation is resumed to dewater the pulp deposited body. After the water content is reduced to a prescribed level, the mold is opened to take out the pulp deposited body.

In the sixth embodiment, the pulp deposited body **5** formed in the first embodiment is dewatered under pressure by using the pressing member **6** as described above, and the mold **10** is opened to take out the pressure dewatered pulp deposited body **5**, which is then set in a heating mold composed of a set of splits **21** and **22** shown in FIG. **9**(*a*). The heating mold has previously been heated to a prescribed temperature. After setting, an edge finishing member **23** comprising a metal-made cylinder, etc. is brought down from above the opening **5'** of the pulp deposited body **5**. The edge finishing member **23** has a smooth and flat lower end. A part of a pressing member **24** of the same material and the same shape as the pressing member **6** used in the pressure dewatering is fixed to the inner wall of the edge, finishing member **23** near the lower end. In this state the upper edge of the opening **5'** of the pulp deposited body **5** is pressed down by the edge finishing member **23**, and, at the same time, the pressing member **24** is inserted inside the pulp deposited body **5**. As shown in FIG. **9**(*b*), it follows that the vicinity of the upper edge is protruded to have an increased thickness, and the shape of the lower end of the edge finishing member **23** is transferred to the upper edge of the opening **5'** of the pulp deposited body **5** thereby to make it smooth and flat. A pressurizing fluid is then fed into the pressing member **24** to press the pulp deposited body **5** onto the inner wall of the split mold **21** and **22** via the pressing member **24** as shown in FIG. **9**(*c*), whereby the pulp deposited body **5** is shaped in conformity to a desired shape and heat dried. After heat drying, the edge finishing member **23** is pulled up, and the pressing member **24** is also taken out of the pulp deposited body **5**. The heating mold is opened to take out the pulp molded article. According to this embodiment, the shape of the opening edge of the pulp molded article can be controlled by appropriately selecting the shape of the lower end of the edge finishing member. As a result, the pulp molded article can have improved sealing properties with a cap, etc. and also improved strength at the opening thereof. In this embodiment, the pressing member **24** does not always need to be fixed to the edge finishing member **23**, in which case the pressing member **24** is inserted either before or after the edge finishing member **23** is pressed down. The material and the shape of the pressing member **24** may be the same as or different from those of the pressing member **6** used for pressure dewatering.

FIG. **10** is a schematic illustration of a molding apparatus used in the seventh embodiment This molding apparatus is roughly divided into a slurry feed section **30** and a papermaking section **40**.

The slurry feed section **30** comprises a slurry storage tank **32** containing a pulp slurry **14**, the tank **32** being equipped with a stirrer **31** for the pulp slurry **14**, an injection pump **33** which sucks up the slurry **14** from the slurry storage tank **32**

and feeds the slurry **14** under pressure into a mold **10**, a flow meter **34** which measures the flow amount of the slurry **14**, a first three-way valve **35** which switches the flow path of the slurry **14** between the direction to the mold and the direction to the slurry storage tank **32** according to the order given by the flow meter **34**, and a second three-way valve **36** which switches the fluid to be fed to the mold **10** between the slurry **14** and air. The slurry storage tank **32**, the injection pump **33**, the flow meter **34**, the first three-way valve **35**, and the second three-way valve **36** are connected in series in the order described through piping **37**.

The papermaking section **40** comprises a mold **10** composed of a set of splits **3** and **4** for papermaking each having a plurality of interconnecting holes (not shown) which connect the outside and the inside, a drain **41** for discharging water of the slurry injected into the cavity **1**, a suction pump **42** which evacuates the cavity **1**, and an on-off valve **43** which connects or disconnects the mold **10** and the suction pump **42**. The slurry is supplied from the slurry feed section **30** to the cavity **1** through the piping **37** and an in-cavity pipe **38**, both the piping **37** and the pipe **38** being connected to the second three-way valve **36**. The in-cavity pipe **38** connected to the second three-way valve **36** is inserted into the cavity **1** through a slurry inlet gate **9**.

The method of producing molded articles by use of the above-described molding apparatus is described below. First of all, the injection pump **33** is started up to suck up the slurry **14** from the slurry storage tank **32**. The slurry **14** passes through the flow meter **34**, the first three-way valve **35**, and the second three-way valve **36** and is injected under pressure into the cavity **1** of the mold **10**. The amount of flow of the slurry **14** is measured with the flow meter **34** in the line. Because the slurry is injected into the cavity **1** under pressure, and the top of the slurry inlet gate **9** is blocked, the water of the slurry injected into the cavity **1** is discharged out of the mold **10** through the interconnecting holes (not shown) which interconnect the inner wall of the cavity **1** to the outside of the mold **10** and through the drain **41**. Meantime the pulp fibers of the slurry are deposited on the inner wall of the cavity **1** to form a pulp deposited body (not shown). Since the slurry injection is under pressure as mentioned above, the pressure of the slurry is equalized all over the inner wall of the cavity **1**. Therefore, even in obtaining a deep molded article whose side walls rise at nearly right angles, a pulp deposited body of uniform thickness is formed on the inner wall of the cavity **1**, and the finally obtained molded article also has a uniform thickness accordingly. Further, since the amount of the slurry to be injected into the cavity **1** is measured in an in line system, papermaking can be performed at a high speed. Furthermore, since the slurry is injected under pressure to cause forced dewatering, the speed of papermaking is further increased.

In order to form a pulp deposited body on the inner wall of the cavity **1** with a uniform thickness and to achieve high-speed papermaking, the pressure for injecting the slurry into the cavity **1** is preferably 0.01 to 5 MPa, particularly 0.01 to 3 MPa

After a predetermined amount of the slurry is injected, the flow meter **34** gives an order to the first three-way valve **35** to make a changeover of the flow path. According to this order, the flow path of the first three-way valve **35** is switched over so that the slurry returns to the slurry storage tank **32** through a return pipe **37**'.

On completion of the slurry injection, the drain **41** is closed to stop drainage. Also, the second three-way valve **36** is switched to change the flow path to connect an air pressure feed pipe **37**" and the in-cavity pipe **38**. Air from an air feed source (not shown) is fed into the cavity **1** under pressure through the air pressure feed pipe **37**" and the in-cavity pipe **38**. Concurrently, the suction pump **42** is started up, and the on-off valve **43** is opened to evacuate the cavity **1**. Through this series of operations the water content in the cavity **1** is completely sucked off, and the water content in the pulp deposited body formed on the inner wall of the cavity **1** is also sucked to dewater the pulp deposited body to a prescribed water content. While the pulp deposited body is dewatered by suction, since the inside of the cavity **1** is pressurized by the air, the pulp deposited body is strongly pressed onto the inner wall of the cavity **1**. As a result, the thickness of the pulp deposited body is leveled more uniformly, and the configuration of the inner side of the cavity **1** is transferred to the pulp deposited body with good precision. Also, dewatering by suction is conducted quickly.

In order to make the thickness of the pulp deposited body more uniform and to achieve quick dewatering, the pressure for feeding air into the cavity **1** is preferably 0.01 to 5 MPa, particularly 0.01 to 3 MPa

After the pulp deposited body is formed in the cavity **1**, the in-cavity pipe **38** is drawn out A pressing member similar to the pressing member **6** used in the first embodiment is inserted into the cavity **1** to dewater the pulp deposited body under pressure. Subsequently, the mold **10** is heated to heat dry the pulp deposited body. Alternatively, the mold **10** is opened to take out the pulp deposited body, which is heat dried in a separately prepared heating mold to obtain a pulp molded article.

In the eighth embodiment, an insert member **50** is inserted into the cavity **1** through the slurry inlet gate **9** of the mold **10** as shown in FIG. **11**(*a*). The cavity configuration of the mold used in this embodiment is conformed to the contour of a carton. The insert member **50** has a supporting member **51** and a hollow or bag-like covering member **52** with which the supporting member **51** is covered. Both the supporting member **51** and the covering member **52** are fixed to a clamp plate **53** with a prescribed means. The supporting member **51** is cylindrical and has a large number of holes **54** on its side. The supporting member **51** has its end **51**a projected outside through the clamp plate **53** and connected to a pressurizing fluid feed source (not shown). There is thus formed a passageway in the insert member **50** from the end **51***a* of the supporting member **51**, through the inside of the supporting member **51** and the holes **54** on the side wall of the supporting member **51** to the inside of the covering member **52**. The covering member **52** is made of a hollow, stretchable elastic member or a nonstretchable bag. Where the covering member **52** is made of an elastic member, the elastic member exhibits elasticity irrespective of whether or not it has a supporting member **51** therein, so that it is easy to keep the elastic member off the inner wall of the cavity **1** in the preliminary expansion hereinafter described. Where, on the other hand, the covering member **52** is made of a nonstretchable bag, the inside of the supporting member **51** is evacuated to bring the bag close to the supporting member **51** so as keep the bag off the inner wall of the cavity **1** while the pulp deposited body is formed. In this particular embodiment, an elastic member is used as the covering member **52**. The elastic member can be made of urethane, fluorine rubber, silicone rubber, elastomers, etc., which are excellent in tensile strength, impact resilience, stretchability, and the like. The nonstretchable bag can be of polyethylene, polypropylene, etc.

With the insert member **50** inserted in the cavity **1** and with the slurry inlet gate **9** blocked by the clamp plate **53**, a

prescribed pressurizing fluid is supplied from a pressurized fluid source into the inside of the covering member **52** through the above-described passageway as shown in FIG. **11**(*b*), thereby to preliminarily expand the covering member **52** to a prescribed size. The covering member **52** thus expanded preliminarily has an almost flat plate shape. The term "expand" as used herein means that the covering member **52** stretches to increase its volume (for example, in the case where the covering member **52** is made of a stretchable elastic member) and that the covering member **52** is not stretchable per se but capable of increasing its volume (for example, in the case where the covering member **52** is made of a nonstretchable bag which is in close contact with the supporting member **51** in an evacuated state). The term "inflate" as used herein has the same meanings.

The above-described preliminary expansion brings about an increase of the volume of the insert member **50**, resulting in a reduction of the capacity of the cavity **1**. This means that the water content of the pulp slurry injected in the cavity **1** decreases. Compared with what would result with no insert member SO, a higher concentration pulp slurry can be injected, and the cavity **1** can be filled with the pulp slurry in a shorter time. As a result, the molding cycle time including the pulp slurry injection time can be shortened. Because the volume of the insert member **50** can be increased within the cavity **1**, the insert member **50** works effectively even in the production of bottles whose cross section at the neck is smaller than the cross section of the body. It is preferred that the capacity of the cavity **1** be decreased by preliminary expansion to 5 to 90%, particularly 40 to 75%, of the capacity before the insertion of the insert member **50**.

While the covering member **52** is in a preliminarily expanded state, any part of the insert member **50** is not in touch with the inner wall of the cavity **1** as depicted in FIG. **11**(*b*). Scatter of thickness of the pulp deposited body **5** is thus suppressed. In this state, a slurry is injected into the cavity **1** through a pulp slurry inlet **54** of the clamp plate **53**, whereupon the water content of the pulp slurry is discharged out of the mold **10** through the interconnecting holes **2**, and pulp fibers are accumulated on the inner wall of the cavity **1**. As a result, there is formed a pulp deposited body **5** built up of the pulp fiber on the inner wall of the cavity **1**.

After a predetermined amount of the pulp slurry has been injected, the feed is stopped, and the cavity **1** is completely evacuated for dewatering. Then, as shown in FIG. **11**(*c*), the pressurizing fluid is further fed into the covering member **52** to further expand the covering member **52**, by which the pulp deposited body **5** is pressed onto the inner wall of the cavity **1** and dewatered under pressure. It is preferred for the pulp deposited body **5** be dewatered by suction to a water content of 70 to 80% by weight and be further dewatered by pressing with the covering member **52** until the water content is reduced to 55 to 70%. Since injection of the pulp slurry into the cavity **1** is immediately followed by pressure dewatering, the time for mechanical operation can be reduced, leading to a reduction of the molding cycle time as compared with the embodiment where an injection nozzle is drawn after the slurry is injected, and an elastic member for pressure dewatering is then inserted. The pressure for feeding the pressurizing fluid for pressure dewatering is preferably 0.01 to 5 MPa, particularly 0.1 to 3 MPa.

After the configuration of the inner side of the cavity **1** is sufficiently transferred to the pulp deposited body **5**, and the pulp deposited body **5** is dewatered to a prescribed water content, the pressurizing fluid in the covering member **52** is withdrawn, whereupon the covering member **52** contracts to its original size as shown in FIG. **11**(*d*). The insert member **50** is taken out of the cavity **1**, and the mold **10** is opened to remove the pulp deposited body **5** having a prescribed water content. The pulp deposited body **5** is subsequently subjected to heat drying in the same manner as in the first embodiment.

The ninth embodiment, shown in FIG. **12**, is the same as the eighth embodiment except for the construction of the pressing member and the step of pressing and dewatering the pulp deposited body.

As shown in FIG. **12**, an insert member **50** is inserted into the cavity **1** of the mold **10** which is composed of a set of splits **3** and **4** butted to each other. The insert member **50** used in this embodiment is a rod having some thickness which is fixed at one end thereof to a clamp plate **53**. In FIG. **12** is shown the side view of the rod. The rod is required to have such a volume as to reduce the capacity of the cavity **1** sufficiently when it is inserted into the cavity **1**. From the standpoint of improvement on efficiency, for example, reduction of the molding cycle time, it is preferred to use a rod having such a volume as to reduce the capacity of the cavity 1 to 5 to 90%, particularly 40 to 75%. As long as this requirement is met, the rod may be either solid or hollow. When the insert member **50** is in an inserted state, any part of the insert member **50** is not in touch with the inner wall of the cavity **4** similarly in the eighth embodiment.

With the insert member **50** inserted and the slurry inlet gate **9** blocked, a pulp slurry is injected into the cavity **1** through a pulp slurry inlet **54**. The water of the pulp slurry is discharged out of the mold **10** through the interconnecting holes **2**, and pulp fibers are deposited on the inner wall of the cavity **1** to form a pulp deposited body. The pulp slurry may be injected through the inside of the insert member **50**.

On injecting a predetermined amount of the pulp slurry, the injection is stopped, and the cavity **1** is completely evacuated for dewatering. Then, the insert member **50** is drawn from the cavity **1**. Thereafter the pulp deposited body is subjected to pressure dewatering and heat drying in the same manner as in the first embodiment.

The tenth embodiment will now be described This embodiment presents an example of production of a multilayered pulp molded article having an outermost layer and an innermost layer.

As shown in FIG. **13**(*a*), a predetermined amount of a first pulp slurry I is injected under pressure into the cavity **1** of the mold **10** through the slurry inlet gate **9**. Pressure injection of the first pulp slurry I can be done by means of, e.g., a pump. The injection pressure of the first pulp slurry I is preferably 0.01 to 5 MPa, still preferably 0.01 to 3 MPa.

The cavity **1** being pressurized, the water of the first pulp slurry is discharged out of the mold **10**, while the pulp fibers are accumulated on the inner wall of the cavity **1** to form a first pulp layer Sa as an outermost layer on the inner wall of the cavity **1** as shown in FIG. **13**(*b*). A second pulp slurry II different from the first pulp slurry I in composition is then injected under pressure into the cavity **1** through the slurry inlet gate **9** of the mold **10**. As a result, there is a mixed slurry comprising the first pulp slurry and the second pulp slurry in the cavity **1**. The injection pressure of the second pulp slurry II can be about the same as that of the first pulp slurry I.

While the second pulp slurry is injected under pressure, dewatering from the cavity **1** is continued to form a mixed pulp layer (not shown) comprising the components of the mixed slurry on the first pulp layer **5***a*. Since the proportion

of the second to the first pulp slurries in the mixed slurry increases continuously with time, the composition of the mixed layer formed on the first pulp layer **5***a* continuously changes from first pulp slurry-rich to second pulp slurry-rich compositions.

As the second pulp slurry II is injected under pressure while continuing pressure dewatering as shown in FIG. **13**(*c*), the composition of the mixed slurry in the cavity **1** finally becomes equal to the composition of the second pulp slurry. Eventually, as shown in the Figure, a second pulp layer **5***b* comprising the component of the second pulp slurry is formed on the mixed layer as an innermost layer.

In the production method according to this embodiment, injection of the first pulp slurry I and that of the second pulp slurry II into the cavity **1** are continuous so that the molded articles can be produced efficiently.

The first and the second pulp slurries are not particularly limited in kind as long as they have different compositions.

After the second pulp layer **5***b* is formed to a prescribed thickness, the pressure injection of the second pulp slurry is ceased, and air is introduced into the cavity **1** under pressure for dewatering. The thus obtained pulp deposited body is subjected to pressure dewatering and heat drying in the same manner as in Example 1 to obtain a multilayered pulp molded article.

The multilayered structure of the molded article obtained by the present embodiment is as shown in FIG. **14**. Between the first pulp layer **5***a* as an outermost layer and a second pulp layer **5***b* as an innermost layer, there exists a mixed layer **5***c* whose composition continuously changes from that of the first pulp layer to that of the second pulp layer. As a result, the adhesion strength between the first pulp layer **5***a* and the second pulp layer **5***b* is increased, and separation of these layers is prevented effectively. The existence of the mixed layer **5***c* between the first pulp layer **5***a* and the second pulp layer **5***b* can be confirmed by microscopic observation of the cross section of the molded article.

The thicknesses of the first pulp layer **5***a*, the mixed layer **5***c* and the second pulp layer **5***b* are decided appropriately according to the use of the molded article and the like. Where, in particular, pulp fiber of low whiteness is used as an inner layer, it is preferred for the outermost layer (the first pulp layer **5***a* in this particular embodiment) to have a thickness of 5 to 50%, especially 10 to 50% of the total thickness of the molded article in order to secure sufficient hiding properties. The thickness of each layer depends on the amounts and the concentrations of the first and second pulp slurries.

Having a multilayer structure, the molded article obtained in this embodiment can have different functions served by the individual layers. For example, only the first pulp layer **5***a* as the outermost layer can be made a colored layer by incorporating a colorant, such as a pigment or a dye, or colored Japanese paper or a colored synthetic fiber into the first pulp slurry. In case where pulp having a relatively low whiteness, for example, pulp obtained from used paper, such as de-inked pulp, is compounded into the first pulp slurry (e.g., to a whiteness of 60% or more, particularly 70% or more), incorporating the colorant only into the first pulp slurry is advantageous in that the tone of that slurry can be adjusted with ease, the amount of the colorant to be compounded can be minimized, and the molded articles can be produced at a lower cost. The amount of the colorant to be added is preferably 0.1 to 15% by weight based on the pulp fiber. Further, the amount of de-inked pulp is reduced, making the molded article inexpensive.

Where a slurry comprising hard wood bleached pulp (LBKP) is used as the first pulp slurry, the resulting molded article has improved surface smoothness and suitability to printing or coating.

Incorporating additives, such as waterproofing agents, water repellents, water-vaporproofing agents, fixing agents, oilproofing agents, antifungal agents, antimicrobial agents, antistatic agents, and the like, into the first pulp slurry imparts the respective functions to the first pulp layer **5***a* as the outermost layer. It is preferred for the first pulp layer **5***a* containing these additives as the outermost layer to have a surface tension of 10 dyn/cm or less and a water repellency of R10 (JIS P 8137). Further, incorporating a particulate or fibrous thermoplastic synthetic resin to the first pulp slurry imparts abrasion resistance to the first pulp layer **5***a* to suppress fluffing and the like. The degree of abrasion resistance is preferably 3H or more in terms of pencil hardness (JIS K 5400).

It is particularly preferred for the pulp slurry to be used for forming the first pulp layer **5***a* as the outermost layer to contain pulp fibers having an average fiber length of 0.2 to 1.0 mm, particularly 0.25 to 0.9 mm, especially 0.3 to 0.8 mm, a Canadian Standard Freeness of 50 to 600 cc, particularly 100 to 500 cc, especially 200 to 400 cc, and such a frequency distribution of fiber length as comprises 50 to 95%, particularly 60 to 95%, especially 70 to 95%, based on the total fiber, of fibers whose length ranges from 0.4 mm to 1.4 mm (range A). Using such a pulp slurry brings about improved transfer of the inner configuration of the cavity.

It is preferred for the pulp slurry to be used for forming the second pulp layer **5***b* as the innermost layer to contain pulp fibers having an average length of 0.8 to 2.0 mm, particularly 0.9 to 1.8 mm, especially 1.0 to 1.5 mm, a Canadian Standard Freeness of 100 to 600 cc, particularly 200 to 500 cc, especially 300 to 400 cc, and such a frequency distribution of fiber length as comprises 20 to 90%, particularly 30 to 80%, especially 35 to 65%, based on the total fiber, of fibers whose length ranges from 0.4 mm to 1.4 mm (range A) and 5 to 50%, particularly 7.5 to 40%, especially 10 to 35%, based on the total fiber, of fibers whose length is more than 1.4 mm and not more than 3.0 mm (range B). Using such a pulp slurry effectively prevents development of cracks and thickness unevenness during papermaking. It is particularly preferred for enhancement of the above effects that the frequency distribution curve has a peak in each of ranges A and B. Where such a pulp slurry is used, the thickness of the innermost layer is preferably 30 to 95%, still preferably 50 to 90%, of the total thickness.

Where it is desired to obtain a certain characteristic by addition of a specified additive or pulp fiber, this can be achieved by adding the additive, etc. only to a specific layer where the desired characteristic is manifested most efficiently. This is advantageous in that the amount of the additive, etc. can be reduced as compared with the production of a monolayer pulp molded article.

According to the present embodiment, it is possible to produce a pulp molded article having more layers than the layer structure shown in FIG. **14**. For example, as shown in FIG. **15**, a third pulp layer **5***d* different in composition from both of the second pulp layer **5***b* and the first pulp layer **5***a* is formed on the side of the second pulp layer **5***b* shown in FIG. **14**, and a mixed layer **5***e* whose composition continuously changes from the composition of the second pulp layer **5***b* to that of the third pulp layer **5***d* is formed between the

second pulp layer **5***b* and the third pulp layer **5***d*, making five layers in all. In this case, a multilayered molded article made up of a plurality of materials is obtained. In another case, another first pulp layer **5***a*' is formed on the side of the second pulp layer **5***b* shown in FIG. **14**, and a mixed layer **5***c*' whose composition continuously changes from the composition of the second pulp layer **5***b* to that of the first pulp layer **5***a*' is formed between the second pulp layer **5***b* and the first pulp layer **5***a*', making five layers in all in which the innermost layer and the outermost layer have the same composition. In this case, making the first pulp layers **5***a* and **5***a*' of pulp having high whiteness and making the second pulp layer **5***b* of pulp having such whiteness as of used paper provide a molded article which has an appearance of high whiteness and yet is competitive in price.

The present invention is not limited to the above-described embodiments so that the steps, apparatus, members and the like in each of the above-described embodiments are interchangeable with each other. The molds that can be used in the present invention may be composed of a set of two or three or more splits in accordance with the shape of articles to be molded. The same applies to the heating molds.

EXAMPLES

The present invention will now be illustrated in greater detail, but it should be understood that the scope of the present invention is not construed as being limited thereto.

Examples 1 to 5

Bottles were molded by the method shown in FIG. **1**. The particulars of the pulp in the slurry used are shown in Table 1 below. Molding properties in the molding are also shown in the Table. In Table 1, the LBKP used in Examples 1 to 4 is used paper used in OA equipment, which contains a large amount of virgin pulp and has a small freeness, while the LBKP used in Example 5 is CENIBRA (trade name), which contains a large amount of recycled pulp with a small amount of virgin pulp and has a large freeness.

TABLE 1

Ex. No.	Raw Material	Avg. Fiber Length (mm)	Freeness (cc)	Fiber Length Frequency Distribution Range A	Range B	Molding Properties
1	used paper	1.50	390	43.4	28.5	good
2	NBKP/LBKP*1 = 70/30*2	1.29	350	57.5	22.0	good
3	used paper/ LBKP*3 = 50/50*2	0.92	350	73.4	9.2	good
4	used paper LBKP*3 = 30/70*2	0.87	450	77.4	7.6	good
5	used paper/ LBKP*4 = 50/50*2	0.92	450	79.7	8.0	good

*1Average fiber length of NBKP: 2.29 mm; average fiber length of LBKP: 0.82 mm
*2Weight ratio
*3Average fiber length of used paper: 1.5 mm; average fiber length of LBKP: 0.82 mm
*4Average fiber length of used paper: 1.5 mm; average fiber length of LBKP: 0.81 mm

As is apparently seen from the results in Table 1, the molded articles of Examples 1 to 5 prepared from a slurry containing pulp having a specific average fiber length, a specific freeness, and a specific fiber length frequency distribution show satisfactory molding properties. While not shown in the Table, the molded articles of Examples 2, 3 and 5 made of a blend of long pulp fibers and short pulp fibers had particularly excellent surface smoothness.

Examples 6 to 9

A slurry for outermost layer containing 1.0% by weight of pulp fiber the physical properties of which are shown in Table 2 was injected into the cavity of the mold shown in FIG. **13** through the slurry inlet gate under a pressure of 0.3 MPa. The cavity was dewatered to form an outermost layer of the slurry for outermost layer on the inner wall of the cavity. Concurrently with the formation of the outermost layer, a slurry for innermost layer containing 1.0% of pulp fiber whose physical properties are shown in Table 2 was injected into the cavity under a pressure of 0.3 MPa. Air is introduced into the cavity through the slurry inlet gate under a pressure of 0.1 MPa to form, on the outermost layer, a mixed layer of which the composition continuously changed from that of the slurry for outermost layer to that of the slurry for innermost layer and, on the mixed layer, an innermost layer was further formed of the slurry for innermost layer. A pressing member comprising an elastic member was inserted into the thus obtained pulp deposited body, and air was fed into the pressing member under a pressure of 1.5 MPa to press the pulp deposited body onto the inner wall of the cavity for dewatering.

The mold was opened to take out the pulp deposited body, which was then set in a heating mold having the same cavity configuration as the shaping mold. A pressing member comprising an elastic member is inserted into the pulp deposited body set in the heating mold. Air was introduced into the pressing member under a pressure of 1.5 MPa to press the pulp deposited body onto the inner wall of the cavity while heating the heating mold at 200° C. to dry the pulp deposited body. After the pulp deposited body dried sufficiently, the heating mold was opened to remove the molded bottle. The molding properties of the resulting molded article are shown in Table 2. The surface roughness of the molded article was measured with Surfcom 120A available from Tokyo Seimitsu K.K. The transfer properties of the inner cavity configuration to the molded article were evaluated with the naked eye. A 70 mm long by 20 mm wide piece was cut out of the resulting molded article. The cut piece was partly separated along the mixed layer to prepare a Y-shaped specimen. The specimen was set on a tensile

tester with a chuck distance of 20 mm and peeled at a peel angle of 180° and a pulling speed of 30 mm/min. The results of the peel test are shown on Table 2. All these results obtained are shown in Table 2.

Examples 10

A bottle was molded in the same manner as in Example 6, except that the slurry for outermost layer was injected into the cavity to complete formation of the outermost layer, and then the slurry for innermost layer was injected into the cavity to form an innermost layer on the outermost layer. The resulting molded article had no mixed layer between the outermost layer and the innermost layer. The same measurements as described above were made on the resulting molded article. The results obtained are shown in Table 2.

What is claimed is:

1. A pulp molded article obtainable by a process comprising:

supplying a pulp slurry into a cavity of a mold composed of a set of splits, the set of splits being assembled together to form said cavity with a prescribed configuration, to form a pulp deposited body, feeding a fluid into said cavity to press said pulp deposited body onto an inner wall of said cavity thereby dewatering said pulp deposited body,

wherein said pulp slurry contains pulp fibers selected from the group consisting of wood pulp fibers which are softwood pulp fibers or hardwood pulp fibers and non-wood pulp fibers having a length-weighted average fiber length of 0.8 to 2.0 mm, a Canadian Standard Freeness of 100 to 600 cc, and a frequency distribution of fiber length as follows: 20 to 90%, based on the total fiber content have lengths from 0.4 mm to 1.4 mm, and 5 to 50%, based on the total fiber content have lengths longer than 1.4 mm and not longer than 3.0 mm.

TABLE 2

	Pulp Fiber of Slurry for Innermost Layer				Pulp Fiber of Slurry for Outermost Layer						Evaluation			
							Fiber Length							
	Avg.		Fiber Length		Avg.		Frequency	Thickness (μm)			Mold-			
Ex. No.	Fiber Length (mm)	Freeness (cc)	Frequency Distribution (%) Range A	Frequency Distribution (%) Range B	Fiber Length (mm)	Freeness (cc)	Distribution (%): Range A	Innermost Layer	Mixed Layer	Outermost Layer	ing Properties	Surface Roughness Ra (μm)	Transfer Properties*	Layer Separation
6	1.50	310	43.4	28.5	0.64	280	72.8	300	100	100	good	2–3	A	not observed
7	1.50	310	43.4	28.5	0.64	280	72.8	200	100	200	good	2–3	A	not observed
8	1.50	310	43.4	28.5	0.48	100	56.3	300	100	100	good	1–2	A	not observed
9	1.50	310	43.4	28.5	0.93	400	73.0	300	100	100	good	3–5	B	not observed
10	1.50	310	43.4	28.5	0.64	280	72.8	350	0	150	good	2–3	A	slightly observed

*A: Neither cracking nor fluffing was observed.
B: No cracks developed, but fluffing was observed.

It is apparently seen from the results shown in Table 2 that the molded articles of Examples of which the innermost and outermost layers are formed by using slurries containing pulp fiber having specific physical properties are prevented from developing cracks or unevenness of thickness (development of a part whose thickness is half or less the average thickness or a part with such a reduced thickness as can be perceived when held up to the light) and have excellent surface smoothness. In particular, the molded articles of Examples 6 to 9 having a mixed layer formed between the innermost layer and the outermost layer have an increased peel strength between the innermost layer and the outermost layer as compared with the molded article of Example 10.

INDUSTRIAL APPLICABILITY

The present invention provides a method of producing a pulp molded article which enables designing a complicated shape and integrally molding an opening portion, a body portion, and a bottom portion with no joint seams. The production method of the present invention is applicable to not only hollow containers to put things in but other objects such as omaments.

2. A pulp molded article obtainable by a process comprising:

supplying a pulp slurry into a cavity of a mold composed of a set of splits, the set of splits being assembled together to form said cavity with a prescribed configuration, to form a pulp deposited body, feeding a fluid into said cavity to press said pulp deposited body onto an inner wall of said cavity thereby dewatering said pulp deposited body,

said pulp molded article having an outermost layer and an innermost layer,

wherein the pulp slurry used to form said innermost layer contains pulp fibers having a length-weighted average fiber length of 0.8 to 2.0 mm, a Canadian Standard Freeness of 100 to 600 cc, and a frequency distribution of fiber length as follows: 20 to 90%, based on the total fiber content of the innermost layer, have fiber lengths from 0.4 mm to 1.4 mm, and 5 to 50%, based on the total fiber content of the innermost layer, have lengths longer than 1.4 mm and not longer than 3.0 mm, and

wherein the pulp slurry used to form said outermost layer contains pulp fibers having a length-weighted average fiber length of 0.2 to 1.0 mm, a Canadian Standard Freeness of 50 to 600 cc, and such a frequency distribution of fiber length as comprises 50 to 95%, based on the total fiber content of the outermost layer, of fibers whose length ranges from 0.4 mm to 1.4 mm.

3. The pulp molded article as claimed in claim **2**,

wherein said pulp slurry is a pulp slurry containing pulp fibers selected from the group consisting of non-wood pulp fibers, softwood pulp fibers and hardwood pulp fibers, and

further comprising a mixed layer which is located in between said outermost layer and said innermost layer, wherein said mixed layer has a composition that continuously changes from that of said outermost layer to that of said innermost layer.

* * * * *

US006315748B1

(12) **United States Patent**
Morgan, Jr.

(10) **Patent No.: US 6,315,748 B1**
(45) **Date of Patent: Nov. 13, 2001**

(54) **METHOD AN APPARATUS FOR TREATMENT OF COMPRESSIVE SYNDROME CONDITIONS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **U.S. Cl.** **602/21**; 128/878; 128/879; 2/20

(58) **Field of Search** 128/846, 878, 128/879, 889; 602/20, 21; 2/16, 20

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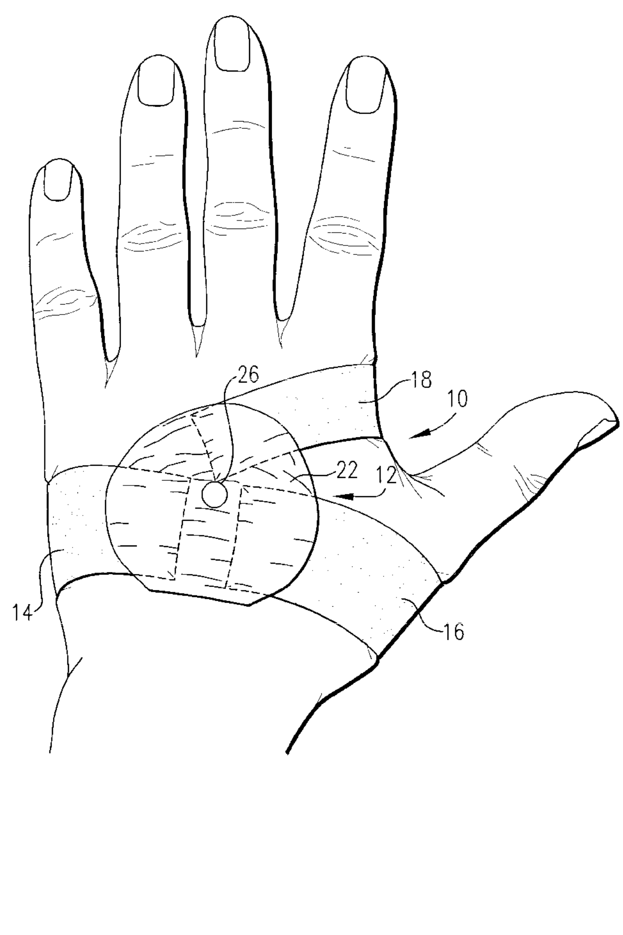
(57) **ABSTRACT**

An orthopedic device (**10**) is provided for the treatment of physical disorders characterized by region(s) of localized, undue compression of body tissue leading to nerve compression and/or damage, such as carpal tunnel syndrome. A carpal tunnel syndrome treatment device (**10**) in accordance with the invention includes a central, resilient, stretchable tensioning segment (**12**) with a plurality of relatively less stretchable adhesive straps (**14–18**) secured to the segment (**12**). In use, the segment (**12**) is placed on the back of a patient's hand (**20**), whereupon the straps (**14–18**) are pulled and adhered to the patient's palm in a fashion to expand the segment (**12**). In this orientation, the control segment (**12**) exerts continuous yielding or tensile forces through the straps (**14–18**) which in turn reduces carpal tunnel syndrome nerve compression and alleviates symptoms.

12 Claims, 2 Drawing Sheets



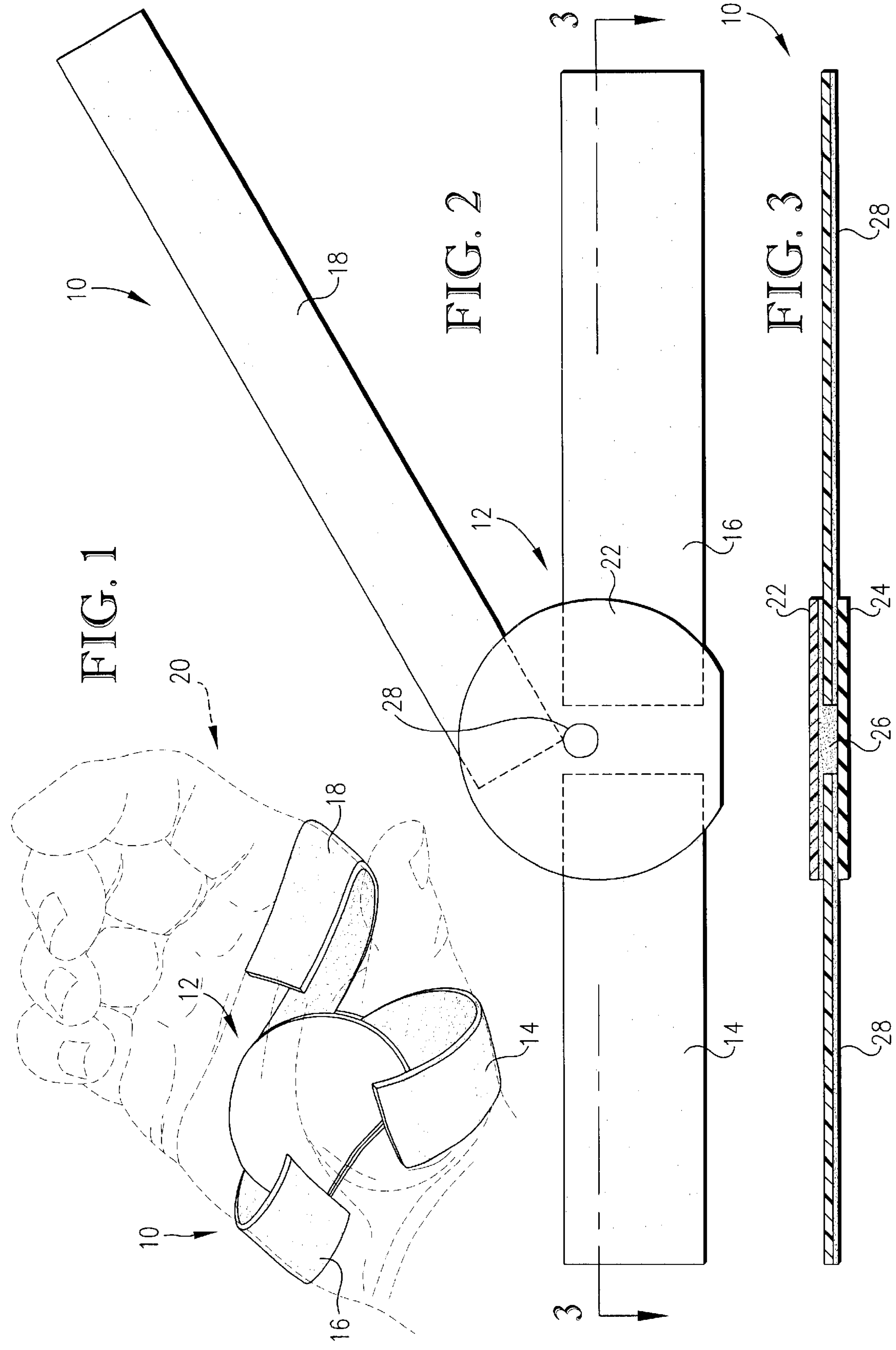


FIG. 1

FIG. 2

FIG. 3

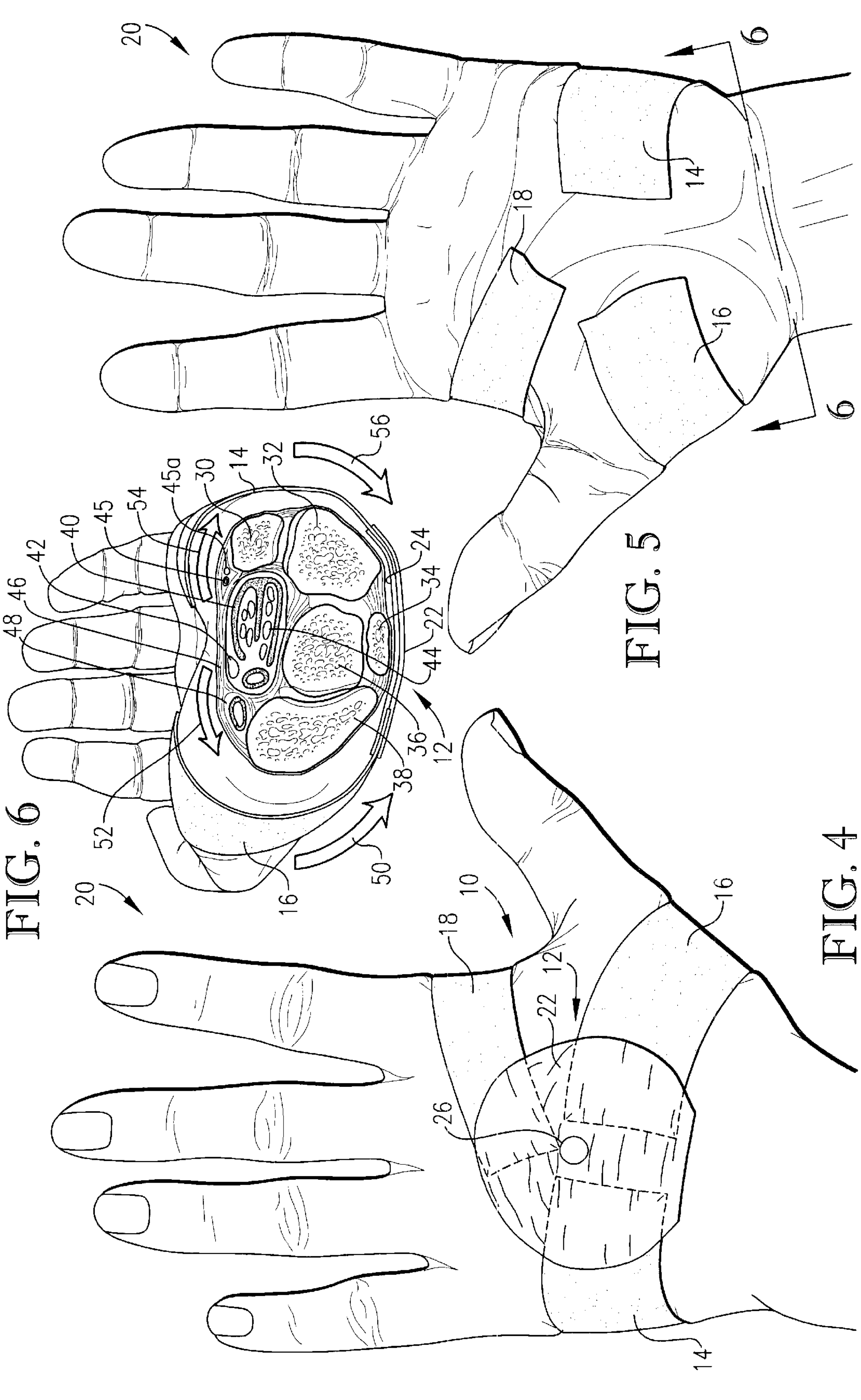


FIG. 4

FIG. 5

FIG. 6

METHOD AN APPARATUS FOR TREATMENT OF COMPRESSIVE SYNDROME CONDITIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is broadly concerned with improved method and apparatus for the treatment of compressive syndrome physical disorders characterized by a region of localized, undue compression of body tissue, for example, carpal tunnel syndrome. More particularly, the invention is concerned with such methods and devices wherein use is made of a central tensioning segment formed of resilient, stretchable material (e.g., synthetic elastomer or latex rubber) together with a plurality of adhesive attachment straps of limited stretchability secured to the tensioning segment for securement of the device on a person's body. The tensioning segment exerts a continuous yielding or tensile force through the straps, serving to at least partially reduce the troublesome tissue compression.

2. Description of the Prior Art

Carpal tunnel syndrome and related conditions result from repeated trauma to the tendons and soft tissue structures forming a part of the wrist. Excessive pressure on the carpal tunnel contents, including the flexor tendons, nerves and bursa, results in abnormal function, weakness, inflammation, pain, numbness and ultimately in nerve tissue injury.

The flexor retinaculum is a thick, relatively unyielding ligamentous band that crosses the groove on the palmer surface of the carpal bones. It is composed of the palmer (volar) carpal ligament and transverse (anterior annular) carpal ligament. The palmer carpal ligament is attached medially and laterally to the styloid processes of the radius and ulna. The transverse carpal ligament is attached medially to the pisiform bone and the hamulus of the hamate, and laterally to the tuberosity of the scaphoid and palmer surface of the ridge of the greater multangular (trapezium). The fibers of these ligaments merge at the distal end of palmer and proximal end of the transverse ligament. Together with the carpal bones and articulations, they form a tunnel through which pass the deep flexor tendons and median nerve.

The median nerve passes through the carpal tunnel adjacent the flexor retinaculum and between it and the flexor tendons and their bursa. The carpal tunnel is barely adequate to accommodate these structures and it is generally felt that any narrowing of the diameter of the tunnel or decrease in the diameter to contents ratio, causes injury to the median nerve by repeatedly pressing it against the relatively unyieldable retinaculum. Repetitive and/or constant forceful movement, in particular extension movements of the hand, are thought to repeatedly traumatize the median nerve in this manner, as does the repetitive and/or constant force contracture of the thenar muscles.

Current medical treatment of carpal tunnel syndrome consists of rest, restriction from traumatizing activities, limiting movement with restrictive splints, anti-inflammatory medication and cortisone injections. In advanced cases surgery is used to transect and spread the transverse carpal ligament to allow more room for the contents of the carpal tunnel, i.e., an increase in the diameter to contents ratio. Some form of wrist support or splint is normally used in the early stages of treatment. They are used in an attempt to delay progression of the condition or as an adjunct to some other treatment in an effort to lessen the pain

and aid in the return to normal function. Subsequent to surgery, wrist splints are frequently used to support the wrist and aid in recovery. Thus it is important that a presurgical device be provided which corrects the condition or prevents further development and/or progression of the condition.

Given the widespread incidence of carpal tunnel syndrome and similar disorders, many attempts have been made to provide orthopedic supports or braces for the wrists which will alleviate the symptoms and/or provide a means of eliminating the problem in its entirety. For example, U.S. Pat. No. 5,921,949 describes a corrective support designed specifically for the treatment of a tunnel syndrome. However, none of these past efforts have resulted in a truly effective device or treatment for the syndrome. Therefore, the traditional treatments described previously remain the methods of choice in most cases.

In addition to carpal tunnel syndrome, a number of other compressive syndrome conditions have been identified. These include radial tunnel syndrome (sometimes referred to as "tennis elbow"). In this condition, the supinator muscle, while turning the wrist in the clockwise direction compresses the radial nerve. The radial nerve feeds the muscles of the back of the forearm. It is most commonly seen with twisting activities of the arm. Pain if first noticed at the lateral side of the elbow, about two inches toward the wrist from the elbow. Rest is currently the best treatment to allow swelling to go down. DeQuervain's Tenosynovitis is a problem of the abductor pollicis longus and extensor policis longus tendons which irritate the bursa coating, called tenosynovius becoming tenosynovitis when inflammation occurs. Irritation continues forming scar tissues. The present treatment protocol attempts to reduce the swelling in the area by reducing the usage.

Frozen shoulder is a joint dysfunction and is often caused by adherence of the anterinferior aspect of the joint capsule to the humeral head. This condition often occurs after injury, being a scar formation type dysfunction. Piriformis Syndrome is a condition where the sciatic nerve is compressed between the piriformis muscle and the gemellus muscle.

Guyons' Canal syndrome is a common nerve compression affecting the ulnar nerve and possibly the ulnar artery as it passes through a tunnel in the wrists on the lateral portion. The problem is similar to carpal tunnel syndrome, but involves a completely different nerve. Sometimes both conditions can be causing problems in the same hand.

Thoracic Kyphosis is the loss of movement in the upper back area, described as a derangement syndrome and is caused by adaptive shortening, as a result from poor postural habits over a sustained period. Derangement syndrome is believed to be caused by a disturbance of some structure with the joint causing mechanical deformation of pain sensitive structures.

Trigger points are muscle conditions where an involved area is relatively spasm, building up lactic acid in the muscle, with resultant pain.

After surgery, scar tissue can ball up and contract, in unnatural orientations. This can cause severe pain to a patient.

While all of these types of compressive syndrome conditions have been recognized for many years, there has been no readily available, non-surgical treatment available to alleviate the symptoms thereof.

SUMMARY OF THE INVENTION

The present invention overcomes the problems outlined above and provides an improved device for the treatment of

compressive syndrome disorders such as carpal tunnel syndrome, but also including radial tunnel syndrome, DeQuervain's Tenosynovitis, frozen shoulder, Piriformis Syndrome, Guyon's Canal Syndrome, thoracic kyphosis, and scar tissue conditions. Broadly speaking, the devices of the invention include a tensioning segment formed of elastic, stretchable material adapted for placement on a persons body proximal to the region of localized tissue compression, together with a plurality of elongated, adhesives straps secured at respective locations to the tensioning segment; the straps have less stretchability (and are preferably essentially non-stretchable) than the tensioning segment and are configured for securing the tensioning segment in place on a person's body. When applied, the tensioning segment of the device exerts yielding or tensile forces through the straps serving to at least partially reduce tissue compression.

In the case of a carpal tunnel syndrome treatment device, the tensioning segment is adapted to overlie the back of a person's hand, and has three individuals straps secured thereto. Two of the attachment straps are oriented to extend end opposite directions from the tensioning segment and to wrap about the heel of the person's hand below the person's thumb; the other of the straps is oriented to wrap about the person's hand between the thumb and forefinger.

In preferred forms, the tensioning segment includes an expansion indicator allowing the user to determine the extent of expansion of the segment upon application of the device. In practice, a circular marking on the tensioning segment is used for this purpose. Additionally, the tensioning segment is preferably formed at least in part of stretchable latex material, whereas the attachment straps are made of essentially nonstretchable polyethylene film coated with pressure are sensitive adhesive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view all of a person's right hand (shown in phantom) with a preferred treatment device in accordance with the invention applied to the person's hand for the treatment of carpal tunnel syndrome;

FIG. **2** is a plan view of the preferred carpal tunnel syndrome treating device in accordance with the invention, with a left hand model being shown;

FIG. **3** is a sectional view taken long line **2**—**2** of FIG. **2** and illustrating one form of interconnection between the central tensioning segment of the device and the adhesive attachment straps;

FIG. **4** is an elevational view of the preferred treatment device of the invention, shown mounted on a person's left hand;

FIG. **5** is a view similar to that of FIG. **4**, but showing the palm side of the person's left hand and the placement of the adhesive straps; and

FIG. **6** is a sectional view along line **6**—**6** of FIG. **5** and illustrating the manner in which the treatment device alleviates the symptoms of carpal tunnel syndrome.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the drawings, and particularly FIGS. **2** and **3**, a carpal tunnel syndrome treating device **10** is illustrated. Broadly speaking, the device **10** includes a central resilient tensioning segment **12** as well as three elongated straps **14**, **16** and **18** secured to be segment **12**. The device **10** is designed to be applied to the hand **20** of a person in order to alleviate carpal tunnel syndrome symptoms.

In more detail, the tensioning segment **12** is made up of a pair of the arcuate, face-to-face oriented flexible sheets **22** and **24**, which are bonded together by adhesive **26** or direct thermal bonding of the sheets. As illustrated, the inboard ends of the straps **14–18** are received and bonded between the sheets **22**, **24**, with the adhesive **26** serving to secure the straps in place; again, if the sheets **22**, **24** are thermally bonded, the straps **14–18** would be secured thereto by virtue of such thermal bonding. An important feature of the invention resides in the fact that the segment **12** is formed of elastic, stretchable material which, when stretched, exerts a continuous yielding or tensile force on the straps **14–18**. To this end, it is preferred that the bottom sheet **24** is formed of conventional synthetic elastomer material, whereas the upper sheet **22** is formed of adhesive-bearing medical tape which is also stretchable with the sheet **24** (in this embodiment, the adhesive forming a part of the medical tape functions as the adhesive **26**; in other cases a separately applied adhesive can be employed). It will also be seen that the upper sheet **22** has an expansion indicator **28** thereon, in the form of a circular marking. Where the tensioning segment **12** is formed of heat-bonded sheets, both such sheets may be formed of appropriate synthetic resin material such as Hysynal commercialized by Hygenic Corporation. The Hysynal product has a 300% modulus (ASTM D412) of 250 psi; a tensile strength (AS TM D412) of 2200 psi; an ultimate elongation ASTM D412) of 600%; and a durometer hardness (ASTM D2240) of 40±5 Shore A (plied). A typical latex rubber used for the fabrication of the segment **12** is the Hytone latex commercialized by Hygenic Corporation. This product has a 300% modulus of 130 psi, a tensile strength of 4000 psi, and an ultimate elongation of 780%.

Generally speaking, stretchable products used in this context should have a modulus of from about 75–400 psi, a tensile strength from about 1500–5000 psi, and an ultimate elongation of from about 200–1000% (ASTM D412).

Each of the straps **14–18** have significantly less stretchability than the tensioning segment **12**. Preferably, these straps are formed of essentially non-stretchable medical quality tape or ethylene vinyl acetate, with a layer **28** of conventional skin adhesive on the underside thereof. This adhesive is advantageously hypoallergenic in order to eliminate skin irritation. As seen, the opposed straps **14** end **16** have a width somewhat greater than that of the angularly oriented strap **18**.

It will be appreciated that the device **10** will be provided in left and right hand versions. The right hand version is illustrated in FIG. **1**, whereas the left hand version is shown in FIGS. **2–5**.

The device **10** is applied to the hand **20** of a person in the general manner shown in FIGS. **1** and **4–5**. That is, in the first step, the tensioning segment **12** is placed on the back of the person's hand. Next, the straps **14** and **16** are sequentially pulled and applied to the palm region of the hand **20** as best seen in FIG. **5**. During this application of the straps **14**, **16**, the user observes the indicator **26**, and pulls the second-applied strap sufficiently to enlarge the indicator by approximately 30%. In the final step, the strap **18** is pulled upwardly and angularly between the thumb and forefinger of the hand, with the outer end of the strap being applied to the palm region of the hand **20** above the ends of the straps **14**, **16**, insuring that the outboard ends of the straps **14–18** do not overlap in the palmar region. Here again, during application of the strap **18**, the indicator circle **26** is used so as to insure a substantially even expansion of the tensioning segment **12**.

In more detail, during the first week of using the device **10**, the tensioning segment **12** is placed on the back side of

the hand, between the first bend of the small finger and where the wrist bends, with the straight edge of the segment **12** at the center of the hand. Next, the strap **14** is applied as described previously, followed by the straps **16** and **18**. During the first week, the device **12** is worn for period of **10–16** hours per day. During the second week of therapy, the segment **12** is placed on the back side of the hand,just distal to where the wrist bends on the side of the little finger, with the edge of the segment at the center of the hand. Placement of the straps **14–18** is the same as during the first week. After the second week, further use of the device **10** is carried out to achieve the most comfort and pain relief for the patient.

Attention is next directed to FIG. **6**, which depicts the manner in which it is believed that the device **10** operates to alleviate the symptoms of carpal tunnel syndrome. As illustrated, the human wrist includes a complex of articulations and tendons including the Pisiform, Triquetral, Lunate, Capitate, and Scaphoid bones **30–38**, respectively, the common synovial sheath **40**, median nerve **42**, digit tendons **44**, ulnar artery **45**, ulnar nerve **45***a*, and flexor retinaculum **46**. The carpal tunnel **48**, through which the median nerve **42** passes, is also illustrated in FIG. **6**. As explained previously, carpal tunnel syndrome involves a condition wherein the median nerve **42** and surrounding tissues are subjected to undue compression, which is accompanied by shortening of the flexor rentinaculum.

Use of the device **10** alleviates carpal tunnel syndrome symptoms by virtue of the continuing yielding or tensile forces exerted on the straps **14–18** by the tensioning segment **12**. That is, and as indicated by directional arrows **50–56**, the segment **12** effectively "pulls" at the area of the carpal tunnel and flexor rentinaculum to lengthen the latter, thereby enlarging the carpal tunnel **48** and relieving pressure on the median nerve **42** and ulnar nerve **45***a*.

The device **10** is also advantageous in that it can be worn by a patient without interfering with the patient's normal activities; indeed, the device can be worn while sleeping or during daytime routines, even under gloves or other protective equipment. At the same time, the invention reduces the possible need for carpal tunnel syndrome surgery and obviates tiresome repetitive exercises and other related physical therapies.

Although a device for treating carpal tunnel syndrome has been specifically illustrated and described herein, it will be appreciated that the invention is not so limited. First and foremost, devices may be provided having as few as two straps and as many as needed for a particular condition. Thus, for the treatment of tennis elbow, it is anticipated that only a two-strap model would be required, with the central tensioning segment applied adjacent the proximal radial head of the radial bone, and with the two-straps extending in opposite directions therefrom. By exerting tension against the stronger muscle in this region, and providing more support for the adjacent weaker muscle, the tendency for the tissue to remain in an abnormal position is lessened, by reducing the intrinsic concentric muscular contraction.

Similarly, scar tissue conditions can be alleviated using devices in accordance with the invention. In such therapy, two of the devices would typically be used, one on each side of the scar formation. In this fashion, a stress is exerted in a direction parallel with the normal fiber orientation so as to stimulate reorientation of the involved scar tissue.

Patients suffering from trigger point muscle conditions can also be helped using the devices hereof. Two approaches can be used in this context. First, the device can be placed with one of the strap ends over the trigger point pain area, with the other strap end over a normal muscle. During motion, the applied device tends to extend the contracted trigger point muscle. Alternately, a plurality of individual devices may be placed about the trigger point muscle area to generate muscle extension forces.

I claim:

1. A device for treating physical disorders characterized by a region of localized, undue compression of body tissue, said device comprising:

a tensioning segment formed of elastic, stretchable material adapted for placement on a person's body proximal to said region; and

a plurality of elongated, adhesive straps secured at respective locations to said tensioning segment, said straps having less stretchability than said tensioning segment and being configured for securing said tensioning segment in place on the person's body, said tensioning segment exerting forces through said straps serving to at least partially reduce said compression at said region.

2. The device of claim **1**, said device adapted for the treatment of carpal tunnel syndrome, said tensioning segment adapted to overlie the back of a person's hand, there being three of said straps secured to said tensioning segment, two of said segments oriented to extend in the opposite directions from said segment to wrap about the heel of the person's hand below the person's thumb, the other of said straps wrapping about the person's hand between the person's thumb and forefinger.

3. The device of claim **1**, said tensioning segment including an expansion indicator permitting the user to determine the extent of expansion of the tensioning segment in different directions, upon attachment of the device.

4. The device of claim **3**, said expansion indicator comprising a circular marking on the outer face of said tensioning segment.

5. The device of claim **1**, said tensioning segment including a pair of opposed, flexible sheets adhesively secured together.

6. The device of claim **5**, the ends of said straps being received and sandwiched between said flexible sheets.

7. The device of claim **1**, each of said straps formed of polyethylene film having one face thereof coated with a pressure sensitive acrylate adhesive.

8. The device of claim **1**, said tensioning segment formed of resilient latex.

9. The device of claim **1**, said device being configured for the treatment of conditions selected from the group consisting of radial tunnel syndrome, DeQuervain's Tenosynovitis, frozen shoulder, Piriformis Syndrome, Guyon's Canal Syndrome, thoracic kyphosis, and scar tissue conditions.

10. A method of treating a physical disorder characterized by a region of localized, undue compression of body tissue, said method comprising the steps of:

placing a tensioning segment on a person's body proximal to said region, said tensioning segment formed of elastic, stretchable material and having a plurality of elongated, adhesive straps secured to the tensioning segment at respective locations of thereon, said straps having less stretchability than said tensioning segment; and

stretching said tensioning segment by exerting tensile forces through said straps, and adhesively attaching said straps on the person's body,

said tensioning segment exerting forces through said straps serving to at least partially reduce said compression at said region.

11. The method of claim **10**, said physical disorder being carpal tunnel syndrome, said placing step comprising the step of placing said tensioning segment on the back of the person's hand, said stretching and attaching step comprising the steps of extending a pair of said straps in opposite directions from said segment and wrapping the straps about the heel of the person's hand below to person's thumb, and

extending a third straps from said tensioning segment and wrapping the third straps about the person's hand between the person's thumb and forefinger.

12. The method of claim **10**, said disorder selected from the group consisting of radial tunnel syndrome, DeQuervain's Tenosynovitis, frozen shoulder, Piriformis Syndrome, Guyon's Canal Syndrome, thoracic kyphosis, and scar tissue conditions.

* * * * *

United States Patent [19]

Weisman et al.

[11] **Patent Number: 4,610,678**

[45] **Date of Patent: Sep. 9, 1986**

[54] **HIGH-DENSITY ABSORBENT STRUCTURES**

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[21] Appl. No.: **529,900**

[22] Filed: **Sep. 6, 1983**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 507,824, Jun. 24, 1983, abandoned, which is a continuation-in-part of Ser. No. 437,846, Mar. 10, 1983, abandoned.

[51] **Int. Cl.**^{4} **A61F 13/16**

[52] **U.S. Cl.** **604/368;** 604/379

[58] **Field of Search** 604/368, 379, 380

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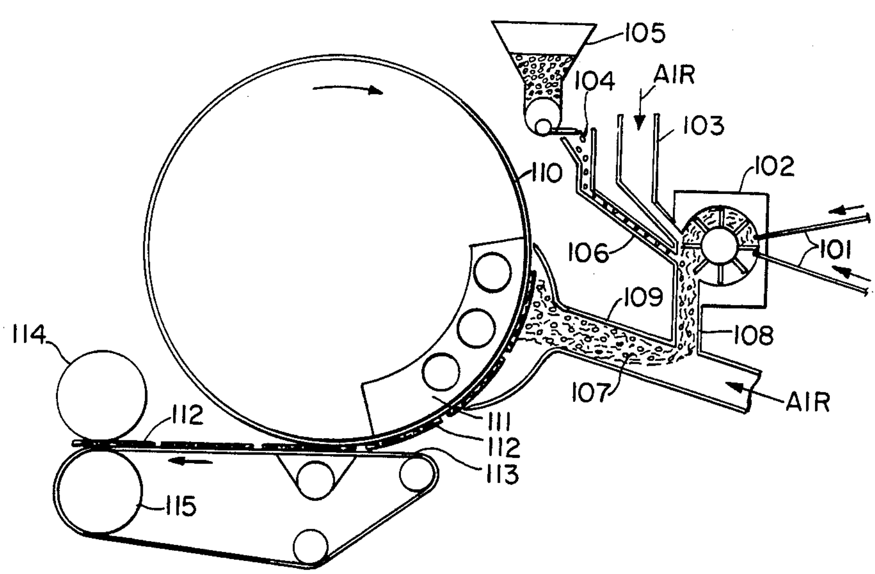
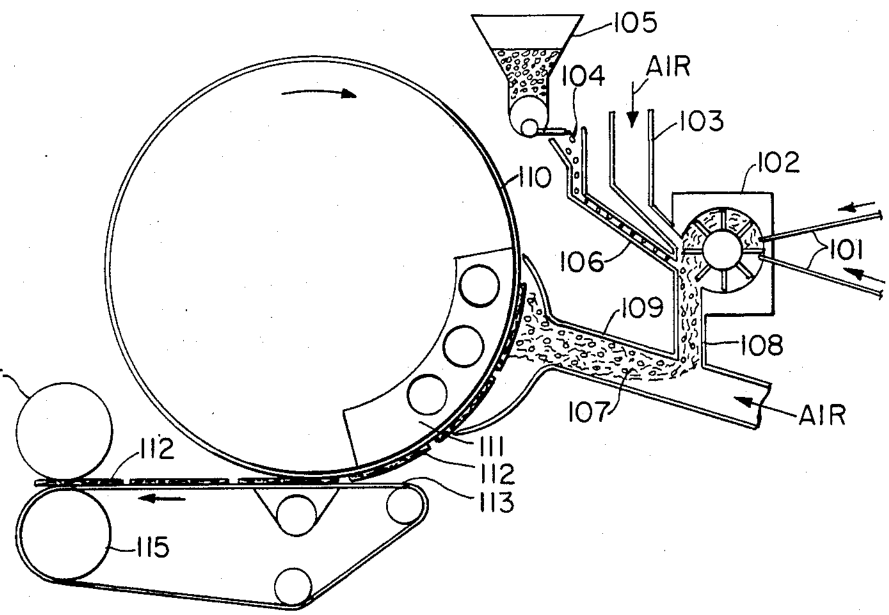
[57] **ABSTRACT**

Absorbent structures comprising a mixture of hydrophilic fibers and discrete particles of a water insoluble hydrogel are disclosed. The fiber/hydrogel ratios range from about 30:70 to about 98:2. The absorbent structures have a density of from about 0.15 g/cm^3 to about 1 g/cm^3. The structures are flexible, and have superior absorption capacities for water and body fluids.

33 Claims, 1 Drawing Figure

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HIGH-DENSITY ABSORBENT STRUCTURES

The present application is a continuation-in-part of application Ser. No. 507,824 filed June 24, 1983, and now abandoned, which is a continuation-in-part of application Ser. No. 437,846 filed Mar. 10, 1983, and now abandoned.

TECHNICAL FIELD

This invention relates to flexible, substantially unbonded, absorbent structures comprising a mixture of hydrophilic fibers and discrete particles of a water-insoluble hydrogel. Flexible absorbent structures, generally non-woven sheets or fibrous webs, have the ability to absorb significant quantities of fluids like water and body exudates. They are used, for example, as disposable towels, facial tissues, toilet tissue, or as adsorbent cores in absorbent products like disposable diapers and sanitary napkins. Generally, such structures are made of inexpensive hydrophilic fibers, typically wood pulp fibers.

Water-insoluble hydrogels are polymeric materials which are capable of absorbing large quantities of water, typically more than 20 times their own weight. When first introduced, these materials were expected to generate a major breakthrough in the world of disposable absorbent consumer products (i.e. products like disposable diapers, sanitary napkins, incontinent pads, and the like). Yet, up to this day, no large-scale use of water-insoluble hydrogels in disposable absorbent products has taken place. The reason is that, in spite of the extremely high water absorption capacities of hydrogels, their performance when used in disposable absorbent products has been unacceptable.

One cause of the poor performance of hydrogels is a phenomenon called gel blocking. The term gel blocking describes a phenomenon that occurs when a hydrogel particle, film, fiber, etc. is wetted; the surface swells and inhibits liquid transmission to the interior. Wetting of the interior subsequently takes place via a very slow diffusion process. In practical terms this means that the absorption is much slower than discharge of fluid to be absorbed, and failure of a diaper or sanitary napkin or other absorbent structure may take place well before the hydrogel material in the absorbent structure is fully wet.

Water-insoluble hydrogels have a water absorbent capacity which far exceeds, generally by far more than an order of magnitude, the absorbent capacity for water of wood pulp fibrous webs which are typically used in disposable absorbent consumer products. The absorption capacity for an electrolyte containing fluid, like urine, is much less but still up to about an order of magnitude higher than that of fibrous webs. Many workers in the field have therefore attempted to somehow incorporate hydrogel materials into wood pulp fiber webs in order to increase the fluid absorption capacities of such webs. Early attempts involved simple mixing of hydrogel powder into the fibrous web. This approach did not lead to any increase of the bulk absorption capacity of the web. (See, for example, R. E. Ericson, "First International Absorbent Products Conference Proceedings", November, 1980, Section 6 at page 3). Ericson reports that "fluid retention under pressure is increased but bulk capacity remains essentially the same". Several explanations for this phenomenon have been given. Ericson ascribes it to the fact that the fibrous matrix prevents swelling of the hydrogel particles. Others believe that the very poor wicking characteristics of hydrogels are responsible for the disappointing performance. Whatever the cause may be, it is well established that simple mixtures of hydrophilic fibers and hydrogel particles do not have the absorption capacity one would expect on the basis of the respective contributions of the components of such mixtures.

Based upon the assumption that the poor wicking of hydrogels causes their poor performance in disposable absorbent structures, some workers in the field have attempted to improve hydrogel performance by introducing fibers into the hydrogel particles. This may be achieved by wet laying of mixtures of hydrogel particles and hydrophilic fibers. During the wet stage of such a process the hydrogel swells. During the drying step the hydrogel tends to retract. As a result the gel spreads over the fiber surface and creates fiber-fiber bonds, in a manner not dissimilar from the bonding which occurs when binders (e.g. latex) are used. As a result of the wet treatment and the bonding by the hydrogel, the resulting absorbent structure is very stiff. It has been disclosed that the stiffness of such structures may be reduced by subjecting the structure to a high pressure. Even when so treated, the stiffness of such structures is still relatively high, especially when fiber/hydrogel ratios of more than 50:50 are used. Such fiber/hydrogel ratios are, however, very desirable from a cost standpoint: hydrogel is far more expensive than, for example, wood pulp fibers. Moreover, the art-disclosed processes involve the handling of large amounts of water and subsequent drying. This adds significantly to the manufacturing costs of the absorbent structures.

Another approach has been to form laminated structures, whereby a layer of hydrogel material is placed against a layer of a material having good wicking properties. The wicking layer spreads the liquid over a larger surface of the hydrogel layer, so that more of the hydrogel is exposed to the liquid to be absorbed. It has been claimed that such structures provide a higher absorption capacity than e.g. mixtures of hydrogel particles in hydrophilic fibrous webs. The wicking layer provides spreading of the liquid across the surface of the hydrogel layer, but does not ensure penetration into the hydrogel layer. The latter liquid movement is still severely limited by gel blocking. In other words, absorbent structures as they are known in the art fail to fully exploit the absorption potential of hydrogels.

There is therefore a continuing need for absorbent structures which are flexible and which more fully exploit the absorbent capacity of hydrogels than has heretofore been possible. The absorbent structures of the present invention provide superior absorbent capacity and excellent wicking properties, and yet are flexible, resilient, and have good lateral integrity. These structures are uniquely adapted for use in disposable diapers which are extremely thin and comfortable but which have an absorbent capacity which is at least equal to the much bulkier products which are currently marketed. The absorbent structures can be made by a process which does not involve water or another solvent. The process therefore does not involve the handling of solvents, or drying. The simplicity of the process permits the use of standard equipment as is currently being used for the manufacture of absorbent webs; it is possible to implement the manufacture of the absorbent structures of the present invention without any major capital investments, and at low per unit manufacturing costs. It is

therefore an object of this invention to provide a flexible absorbent structure which comprises a water-insoluble hydrogel, having improved absorbent properties. It is a further object to provide improved disposable absorbent products, such as diapers, which are substantially thinner and less bulky than conventional disposable absorbent products. It is a further object of this invention to provide a process for making such absorbent structures.

RELEVANT REFERENCES

The gel blocking phenomenon has been well documented, and the resulting poor properties of absorbent structures comprising hydrogels have been discussed: see, for example, E. Carus, "First International Absorbent Products Conference Proceedings", November, 1980, Section V-1; and J. H. Field, "Pulp Parameters Affecting Product Performance", TAPPI, 65(7) 1982, pp. 93–97.

Japanese Patent Specification 56-65630, published June 3, 1981, discloses a process for preparing "tufted lumps" of cellulose fiber holding water-insoluble resins. The lumps are prepared by dispersing the fibers and the resin in methanol, wet-laying the mixture and drying off the solvent. The web is subsequently compressed to a density of more than 0.1 g/cm^3, preferably about 0.6 g/cm^3. The sheet thus obtained is cut into pieces of less than 0.5 g each. A similar approach is taken by Kopolow, U.S. Pat. No. 4,354,901, issued Oct. 19, 1982. This reference discloses a process whereby a slurry is formed of less than about 0.1% by weight solids in water, the solids being a mixture of cellulose fibers and particulate hydro-colloidal material. A wet web is formed from the slurry which is subsequently dried and densified by at least 10%, preferably at least 50%. It is said that the densifying step results in reduction of the stiffness of the absorbent structure (Gurley Stiffness values of less than 40 g).

SUMMARY OF THE INVENTION

This invention relates to a flexible, substantially unbonded, absorbent structure comprising a mixture of hydrophilic fibers and discrete particles of a water-insoluble hydrogel, in a fiber/hydrogel ratio of from about 30:70 to about 98:2; said absorbent structure having a density of from about 0.15 to about 1 g/cm^3.

This invention further relates to a process for making a flexible absorbent structure, comprising the following steps: (a) air-laying a dry mixture of hydrophilic fibers and particles of a water-insoluble hydrogel in a fiber/hydrogel weight ratio of from about 30:70 to about 98:2 into a web; and (b) compressing the web to a density of from about 0.15 to about 1 g/cm^3.

BRIEF DESCRIPTION OF THE DRAWING

The drawing schematically illustrates one embodiment of the process for preparing the absorbent structures of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The basis of this invention is the discovery that mixtures of hydrophilic fibers and particles of water-insoluble hydrogels may be formed into flexible, highly absorbent structures, provided that the weight ratio of fiber/hydrogel is between about 30:70 to about 98:2; and further provided that the structure is densified to a density of from about 0.15 to about 1 g/cm^3. The absorbent structures of the present invention are basically webs of hydrophilic fibers, having dispersed therein discrete particles of the water-insoluble hydrogel. The hydrogel particles may be randomly dispersed, or in a pattern of areas with a low fiber/hydrogel ratio, and areas of a high fiber/hydrogel ratio (which includes areas of fiber alone).

By "substantially unbonded" is meant that the number of fiber/fiber bonds, fiber/hydrogel particle bonds and hydrogel particle/hydrogel particle bonds is kept as low as reasonably possible. Bonds which may occur include hydrogen bonds (like paper-making bonds), other types of chemical bonds as may occur between fibers and hydrogel particles, among hydrogel particles, and among certain types of fibers (e.g. thermoplastic fibers) and mechanical bonds. This is important because the high absorbent capacities of the absorbent structures of the present invention are due to a significant extent to their ability to quickly regain volume upon initial wetting. A large number of bonds among the constituents of the structure would seriously impair this ability.

It is virtually impossible to entirely prevent bonds from being formed. However, some modest degree of bonding does not appear to negatively affect the structures' ability to quickly regain volume upon initial wetting. Generally, the degree of bonding is minimized by avoiding exposure of the fibers and hydrogel particles, or the absorbent structures, to water in its liquid form, and by avoiding prolonged exposure to air which has a high relative humidity. These process parameters are discussed in more detail hereinbelow.

By "hydrogel" as used herein is meant an inorganic or organic compound capable of absorbing aqueous fluids and retaining them under moderate pressures. For good results, the hydrogels must be water insoluble. Examples are inorganic materials such as silica gels and organic compounds such as cross-linked polymers. Cross-linking may be by covalent, ionic, vander Waals, or hydrogen bonding. Examples of polymers include polyacrylamides, polyvinyl alcohol, ethylene maleic anhydride copolymers, polyvinyl ethers, hydroxypropyl cellulose, carboxymethyl cellulose, polyvinyl morpholinone, polymers and copolymers of vinyl sulfonic acid, polyacrylates, polyacrylamides, polyvinyl pyridine and the like. Other suitable hydrogels are those disclosed in U.S. Pat. No. 3,901,236, issued to Assarsson et al., Aug. 26, 1975, the disclosures of which are incorporated herein by reference. Particularly preferred polymers for use herein are hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates, and isobutylene maleic anhydride copolymers, or mixtures thereof.

Processes for preparing hydrogels are disclosed in U.S. Pat. No. 4,076,663, issued Feb. 28, 1978 to Fusayoshi Masuda e al.; in U.S. Pat. No. 4,286,082, issued Aug. 25, 1981 to Tsuno Tsubakimoto et al.; and further in U.S. Pat. Nos. 3,734,876, 3,661,815, 3,670,731, 3,664,343, 3,783,871, and Belgian Pat. No. 785,858; the disclosures of all of which are incorporated herein by reference.

As used herein "Particles" include particles of any shape, e.g. spherical or semi-spherical, cubic, rod-like, polyhedral, etc.; but also shapes having a large greatest dimension/smallest dimension ratio, like needles, flakes and fibers, are contemplated for use herein. By "particle size" as used herein is meant the weight average of the smallest dimension of the individual particles. Conglomerates of hydrogel particles may also be used, pro-

vided the weight average size of such conglomerates is within the limits set forth hereinbelow.

Although the absorbent structures of the present invention are expected to perform well with hydrogel particles having a particle size varying over a wide range, other considerations may preclude the use of very small or very large particles. For reasons of industrial hygiene, (weight) average particle sizes smaller than about 30 microns are less desirable. Particles having a smallest dimension larger than about 4 mm may cause a feeling of grittiness in the absorbent structure, which is undesirable from a consumer standpoint. Preferred for use herein are particles having an (weight) average particle size of from about 50 microns to about 1 mm.

The type of hydrophilic fibers is not critical for use in the present invention. Any type of hydrophilic fiber which is suitable for use in conventional absorbent products is also suitable for use in the absorbent structure of the present invention. Specific examples include cellulose fibers, rayon, polyester fibers. Other examples of suitable hydrophilic fibers are hydrophilized hydrophobic fibers, like surfactant-treated or silica-treated thermoplastic fibers. Also, fibers which do not provide webs of sufficient absorbent capacity to be useful in conventional absorbent structures, but which do provide good wicking properties, are suitable for use in the absorbent structures of the present invention. This is so because, for the purposes of the present invention, wicking properties of the fibers are far more important than their absorbent capacity. For reasons of availability and cost, cellulose fibers, in particular wood pulp fibers, are preferred.

The relative amount of hydrophilic fibers and hydrogel particles are most conveniently expressed in a weight ratio fiber/hydrogel. These ratios may range from about 30:70 to about 98:2. Low fiber/hydrogel ratios, i.e. from about 30:70 to about 50:50, are practicable only when the hydrogel used possesses a low swelling capacity i.e., hydrogels having an absorbent capacity for urine and other body fluids of less than about 15 times their own weight (15×). (Absorbent capacity data are generally available from the manufacturer of the hydrogel; or may conveniently be determined by means of the absorption/desorption test described hereinbelow). Hydrogels which have a very high absorption capacity (i.e. 25×, and which consequently exhibit a high degree of swelling after wetting) tend to gel block when used in absorbent structures at low fiber/hydrogel ratios, which causes undesirable, slow, diffusion type absorption kinetics. Very high fiber/hydrogel ratios, e.g. above 95:5 on the other hand, provide meaningful performance benefits only if the hydrogel used has a high absorbent capacity (e.g., 25× for urine and other body fluids). For most commercially available hydrogels the optimum fiber/hydrogel ratio is in the range of from about 50:50 to about 95:5.

Based on a cost/performance analysis, fiber/hydrogel ratios of from about 75:25 to about 90:10 are preferred. This preference is, of course, based on the relative costs of hydrophilic fibers (e.g. wood pulp fibers) and hydrogel. If, for example, wood pulp prices would go up and/or hydrogel prices would come down, lower fiber/hydrogel ratios would be more cost effective.

The density of the absorbent structure is of critical importance. When hydrogel particles are dispersed into an absorbent web of hydrophilic fibers having a density of about 0.1 g/cm^3, the admixture of the hydrogel results in only a small increase in the amount of fluid which is absorbed within a practicably reasonable time (e.g. 10 minutes) because the fluid uptake of such webs is slow. When the absorbent structure is densified to a density of at least about 0.15 g/cm^3, a marked increase in absorbent capacity is observed. Moreover, the fluid uptake becomes much faster upon densification. The capacity increase is surprising because densifying the web will result in reducing the void volume of the dry structure. It is believed that densifying the web results in better wicking of fluid into the web, so that more hydrogel particles participate in the absorption process, which results in a higher actual absorbent capacity. It is further believed that a densified web may be more effective in keeping the hydrogel particles isolated from each other. Densifying the web further, from about 0.15 g/cm^3 to about 1 g/cm^3, results in a reduction in the bulk of the structure (which is desirable from a consumer standpoint, for aesthetics reasons), without loss of absorbent capacity. However, above a density of about 0.6 g/cm^3, further densification hardly reduces the bulk further, because of the inverse relationship between bulk and density. The densities of the absorbent structures of the present invention are therefore preferably in the range of from about 0.15 to about 0.6 g/cm^3, and more preferably within the range of from about 0.25 to about 0.4 g/cm^3.

The continuous flexible absorbent structures of the present invention can be made by a process comprising the steps of (a) air-laying a dry mixture of hydrophilic fibers and particles of a water-insoluble hydrogel in a weight ratio of from about 30:70 to about 98:2; and (b) compressing the web to a density of from about 0.15 to about 1 g/cm^3. Step (a) may be accomplished by metering an air flow containing hydrophilic fibers and an air flow containing hydrogel particles onto a wire screen. The fibers and the particles become mixed by turbulence of the two air flows as they meet. Alternatively, the fibers and the hydrogel may be mixed in a separate mixing chamber prior to air-laying.

For the purpose of the present invention it is essential that dry hydrogel particles are used. Also, neither the fibers, the particles nor the mixture of fibers and particles should be exposed to water in its liquid form, or another solvent, at any time during this process or subsequent thereto. When wet hydrogel particles are used, the fibers tend to become entangled and/or bonded with the particles which results in undesirable stiffness of the absorbent structure. Especially when cellulose fibers, e.g. wood pulp fibers, are used as the hydrophilic fibers in the absorbent structures of the present invention, the softness of these structures can be improved by adding small quantities of chemical debonding agents (cationic, nonionic or anionic surfactants) to the fibers. Examples of suitable debonding agents are disclosed in U.S. Pat. No. 3,821,068, issued June 28, 1974 to Shaw, the disclosures of which are incorporated herein by reference. Particularly suitable debonding agents are quaternary ammonium compounds of the type disclosed in U.S. Pat. No. 3,554,862, issued Jan. 12, 1971 to Hervey et al., incorporated herein by reference. Preferred quaternary ammonium compounds are those having the general formula

$$\left[\begin{array}{c} R_1-O-(C_2H_4O)_n-CH_2-CHOH-CH_2 \quad\quad R_3 \\ \quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \overset{\oplus}{N} \\ R_2-O-(C_2H_4O)_m-CH_2-CHOH-CH_2 \quad\quad R_4 \end{array}\right] X^{\ominus}$$

wherein R_1 and R_2 are hydrocarbyl groups containing from about 8 to about 22 carbon atoms, R_3 and R_4 are alkyl having from 1 to 6 carbon atoms; n and m are integers from 2 to about 10, and X is halogen. Examples of such compounds are disclosed in U.S. Pat. No. 4,144,122, issued Mar. 13, 1979 to Emanuelsson et al., incorporated herein by reference.

Typically, the amount of chemical debonding agent in the absorbent structures is from about 0.01% to about 0.5% by weight of the hydrophilic fibers.

As used herein, "dry" does not mean "absolutely water-free". For example, under normal storage and handling conditions, hydrogel particles take up some moisture. The hydrophilic fibers also take up some moisture during storage. Furthermore, it may be desirable to use humidified air for air transport of the fibers and the hydrogel particles, to avoid dusting. Under such process conditions, the hydrogel particles and the fibers will take up even more moisture, but this does not negatively affect the practice of the present invention. However, contact times of the hydrogel with conveying air are short, and the limited water-uptake by the hydrogel during air-conveying with humidified air will not result in substantial bonding of the structure. The important criterion is that the hydrogel particles should not be allowed to swell appreciably, and should not develop a surface stickiness to a point that it results in entanglement and/or bonding of the fibers. Generally, this can be achieved by exposing the hydrophilic fibers and the hydrogel particles only to water vapor, and not to water in its liquid form. Even mere exposure of the hydrogel to humidified air may result in substantial bonding of the structure during subsequent processing, especially during calendering, if such exposure is prolonged. For example, in U.S. Pat. No. 4,252,761, issued Feb. 24, 1981 to Schoggen et al., the entire thrust is to expose specific hydrogel imaterials to levels of water which result in bonded structures which are unacceptable for the purpose of the present invention due to unacceptable initial absorption kinetics. In order to ensure that the structure remains substantially unbonded the moisture content of the absorbent structure must be less than about 10% by weight of the dry absorbent structure.

The absorbent structures may conveniently be made by using conventional equipment designed for air laying of hydrophilic fibrous webs. In such equipment, webs are typically formed by taking up hydrophilic fibers in an air flow and depositing the fibers on a wire mesh screen. By metering the desired quantities of hydrogel particles into the air flow at a point just upstream of the wire mesh screen, the desired mixture of hydrophilic fibers and hydrogel particles can be made. The web formed on the screen is then passed through calender rolls which are set to a nip pressure resulting in the desired density of the absorbent structure. It will be clear that this embodiment of the process requires only minor modifications of conventional equipment for the manufacture of absorbent structures, i.e. installing a metering device for the addition of the hydrogel particles. In certain instances it may be necessary to replace the standard wire mesh screen on the equipment with one of a finer mesh size. This need will arise when relatively small hydrogel particles are used, and/or when the mesh size of the standard screen is relatively coarse.

The process of preparing the absorbent structures of the present invention is illustrated by the drawing. In this process sheets of dry lap **101** are fed to a hammer mill **102** wherein the dry lap is disintegrated into cellulose fibers. Such fibers are blown from the hammer mill using air entering through conduit **103**. Particles of hydrogel **104** are fed to the system from a hydrogel feed hopper **105** via conduit **106**. The mixture **107** of cellulose fibers and hydrogel particles is removed from the hammer mill via conduit **108** and propelled through conduit **109** by an airstream. An intimate admixture of the fibers and hydrogel particles is formed in the conduit **109**.

The mixture **107** of cellulose fibers and hydrogel particles is deposited on the screen surface **110** of a forming drum **111**, the inside of which is maintained under vacuum. The mixture of cellulose fibers and hydrogel particles intermittently deposited on the screen forms discrete fiber webs **112** on the surface of the forming drum. These webs **112** are removed from the forming drum and deposited onto a transfer screen **113**. The webs **112** on the transfer screen then pass between upper and lower calender rolls **114** and **115** which serve to compress the webs **112** to the desired density, thereby forming the absorbent structures of the present invention.

Because of their particular properties, the absorbent structures of this invention are extremely suitable for use in disposable absorbent products. By "absorbent product" herein is meant a consumer product which is capable of absorbing significant quantities of water and other fluids, like body fluids. Examples of absorbent products include disposable diapers, sanitary napkins, incontinence pads, paper towels, facial tissues, and the like. As compared to conventional hydrophilic fibrous webs, the absorbent structures of this invention have a high absorbent capacity, a high density, and a flexibility which is at least equal to that of conventional fibrous webs. For these reasons, these absorbent structures are particularly suitable for use in products like diapers, incontinent pads, and sanitary napkins. The high absorbent capacity and the high density make it possible to design absorbent products which are thin and yet have more than sufficient absorbent capacity to avoid the embarrassment of failure. Flexibility of the structure ensures comfort for the wearer and a good fit of the absorbent product. The high density/low volume of the products will also result in important packaging and transport cost savings for the manufacturer.

Disposable diapers comprising the absorbent structures of the present invention may be made by using conventional diaper making techniques, but replacing the wood pulp fiber web ("air-felt") core which is typically used in conventional diapers with an absorbent structure of the present invention. Thus, a disposable diaper may be comprised of (from top to bottom) a top sheet (a non-woven, hydrophobic tissue, e.g. needle punched polyester), the absorbent structure, and a waterproof, pliable back sheet (e.g. hard polyethylene, having an embossed caliper of approximately 2.3 mils.). Optionally, the absorbent structure may be wrapped in envelope tissue (wet strength tissue paper). Disposable diapers of this type are disclosed in more detail in U.S.

Pat. No. 3,952,745, issued Apr. 27, 1976 to Duncan; and in U.S. Pat. No. 3,860,003, issued Jan. 14, 1975 to Buell, the disclosures of which are incorporated herein by reference.

Since the absorbent structures of the present invention have a higher absorbent capacity than conventional wood pulp fiber webs, the wood pulp web may be replaced with an absorbent structure of the present invention of less than equal weight. The reduced weight and the higher density combined account for a reduction in bulk by a factor 3 to 12 or more (depending on the type of hydrogel, the fiber/hydrogel ratio, and the density used).

The amount of absorbent structure used in disposable diapers is conveniently expressed as the basis weight (in g/cm^2) of the structure. Typically, basis weights of the absorbent structures of the present invention as used in disposable diapers range from about 0.01 g/cm^2 to about 0.05 g/cm^2. One way in which this invention may be used is in manufacturing diapers having both increased absorption capacity and reduced bulk as compared to conventional diapers. This can be obtained by using absorbent structures having a basis weight of from about 0.018 to about 0.03 g/cm^2. Preferred are basis weights of from about 0.019 to about 0.021 g/cm^2. A different approach is to aim at an absorbent capacity substantially equivalent to that of conventional diapers, while fully exploiting the potential of bulk reduction offered by this invention. This is generally achieved by using basis weights of from about 0.01 to about 0.017 g/cm^2. Preferred are basis weights in the range from about 0.014 to about 0.017. The absorbent structures used in disposable diapers preferably have a thickness of from about 0.3 mm to about 2 mm, more preferably from about 0.5 mm to about 1 mm.

Conventional disposable diapers are usually comprised of (from top to bottom) a top sheet (a non-woven, hydrophobic tissue, e.g., needle punched polyester), a wood pulp fiber absorbent core, and a waterproof, pliable back sheet (e.g., hard polyethylene having an embossed caliper of approximately 2.3 mils.). The absorbent capacity of such diapers is substantially increased when an absorbent structure of the present invention is placed between the wood pulp fiber core and the back sheet. When used in this manner the absorbent structures preferably have a thickness of from about 0.1 mm to about 1 mm. The absorbent structure used as an insert can have the same size and shape as the wood pulp fiber core, or be different. In a specific embodiment the wood pulp fiber core is hourglass shaped (i.e., the width in the center of the core is substantially less than the width at the ends), and the absorbent structure is rectangular, having a length approximately the same as the length of the wood pulp fiber core, and a width of from about 1 cm to about 5 cm less than the width of the wood pulp fiber core at the narrowest point of the hourglass.

Because the absorbent structures of the present invention are highly absorbent, and yet thin and flexible, they are extremely suitable for use in sanitary napkins. As is the case with disposable diapers, sanitary napkins utilizing the present absorbent structures may be derived from conventional sanitary napkins by simply replacing the absorbent core thereof (typically a web of wood pulp fibers) with an absorbent structure of the present invention. Such replacement may be on a weight-by-weight basis, which results in a reduction in volume and a gain in capacity; or the replacement may be on a less than equal weight basis, thereby sacrificing part of the gain in absorbent capacity in favor of an even greater reduction in bulk. The absorbent structures used in sanitary napkins preferably have a thickness of from about 0.1 mm to about 2 mm, more preferably from about 0.3 mm to about 1 mm.

An example of a sanitary napkin comprises a pad of the absorbent structure of the present invention; a hydrophobic topsheet; and a fluid impervious bottom sheet. The topsheet and the backsheet are placed at opposite sides of the absorbent structure. Optionally, the absorbent structure is wrapped in envelope tissue. Suitable materials for top sheets, bottom sheet and envelope tissue are well known in the art. A more detailed description of sanitary napkins and suitable materials for use therein is found in U.S. Pat. No. 3,871,378, issued Mar. 18, 1975 to Duncan et al., the disclosures of which are incorporated herein by reference.

PERFORMANCE TESTING

A. Partitioning Test

Samples of absorbent structures were subjected to a partitioning test, more fully described hereinbelow. This test has been designed to measure the absorption performance of absorbent structures in competition with conventional cellulose fibrous webs, both under conditions of low liquid load and high liquid loads. The absorption fluid was "synthetic urine" (a solution of 1% NaCl, in distilled water; the surface tension of the solution was adjusted to 45 dynes/cm with about 0.0025% of an octylphenoxy polyethoxy ethanol surfactant (Triton X-100, from Rohm and Haas Co.). This test has been found to be predictive of the absorption capacity under typical usage conditions of absorbent structures when used as absorbent cores in diapers.

Absorbent structures were made by metering predetermined amounts of hydrogel particles into a flow of air containing southern soft wood slash pine fibers; the mixture was air laid on a wire mesh screen and the resulting web was densified between calender rolls to the required density. The structures had a basis weight of 0.04 g/cm^2. On the same equipment, webs of southern soft wood slash pine fibers were made, also having a basis weight of 0.04 g/cm^2 and calendered to a density of 0.1 g/cm^3. No hydrogel particles were added to the latter webs. The latter web served as the reference in all tests. Round samples of 6 cm diameter were punched out of the sheets of absorbent material for partitioning testing.

The partitioning tests were carried out as follows. A piece of polyethylene sheet (the kind of material generally used as a backsheet in disposable diapers) was placed on a flat, nonabsorbent surface. A round sample (6 cm diameter) of the absorbent structure to be tested was placed on top of this backsheet. On top of that was placed a piece of paper tissue of the type generally used as envelope tissue in disposable diapers. On top of the envelope tissue was placed a sample of the reference material (southern soft wood slash pine fibrous web, 0.1 g/cm^3 density). The top sample was wetted with a predetermined amount (about 1 g) of synthetic urine, covered with another piece of backsheet, upon which a weight of 4.4 pounds (about 2 kg) was placed. This weight exerts a confining pressure of 1 psi (about $70\times10^3 N/m^2$). After five minutes equilibration time, the weight was removed and the two samples of absorbent material were weighed separately. The "loading", defined as the amount of synthetic urine (in grams)

absorbed per gram of absorbent material was calculated for each sample. The sample was then dosed with an additional dose of synthetic urine, placed back under the confining weight, equilibrated, and weighed. This was repeated several times (typically on the order of 8–10 times) so that the relative absorption performance of the test material over a wide range of total loadings was obtained. The loading of the bottom test layer was then plotted as a function of the loading in the reference top layer.

Of particular interest are the loadings of the test layer at the points where the loading of the reference is 2.0 g/g and 4.5 g/g respectively. The loading of the test layer at the reference loading of 4.5 g/g has been found to be predictive of the loading at failure in normal use when the test material is used as a core in a disposable diaper. The loading of the test layer at a loading of the reference layer of 2.0 g/g is representative of the loading of the diaper under typical usage conditions. All experimental results reported herein are average results of duplicate or triplicate experiments.

B. Absorption/Desorption Test

The absorption properties of absorbent structures were determined by their "synthetic urine" absorption and desorption behavior. The basis procedure and the design of the apparatus are described by Burgeni and Kapur, "Capillary Sorption Equilibria in Fiber Masses", *Textile Research Journal,* 37 (1967) 362, which publication is incorporated herein by reference. The test is particularly useful for determining absorption kinetics.

The absorption apparatus consisted of a horizontal capillary tube, approximately 120 cm long, connected by a valve to a fluid reservoir. The end of the tube was connected by tygon tubing to a glass funnel containing an ASTM 4–8 micron frit on which the absorbent web sample was placed. The glass frit funnel was mounted on a vertical pole. The height of the frit above the capillary tube determined the hydrostatic suction being exerted on the sample. In a typical absorption/desorption experiment the volume of absorbed synthetic urine was determined as a function of hydrostatic suction, starting at 100 cm (corresponding with a hydrostatic pressure of −100 cm).

A simplified test was developed to determine the useful capacity of an absorbent web. In this test, the absorbed volume at −25 cm hydrostatic pressure was measured ("25 cm, absorption"). Next, the frit containing the sample was lowered to zero hydrostatic pressure and the equilibrium value of sorbed volume measured ("0 cm, void volume"). Then the frit was raised again to the 25 cm mark and the absorbed volume at −25 cm in the desorption mode was determined ("25 cm, desorption").

C. Gurley Stiffness Test

The stiffness of absorbent structures was determined using a Gurley Stiffness Tester (manufactured by W. and L. E. Gurley of Troy, New York). The use of this tester is disclosed in U.S. Pat. No. 4,354,901, issued Oct. 19, 1982 to Kopolow, which disclosure is incorporated herein by reference. In essence, this instrument measures the externally applied force required to produce a given deflection of a strip of material of specific dimensions, fixed at one end and having a load applied to the other end. The results were obtained as "Gurley Stiffness" values in units of grams. Each strip of absorbent material was 3.5 inches by one inch (about 8.9 cm×2.5 cm).

The absorbent structures of the present invention have a Gurley Stiffness value of less than 2 g, preferably less than about 1 g, when measured on a strip having a basis weight of 0.03 g/cm^2.

EXAMPLE I

In order to test the effect of fiber:hydrogel ratios on the partitioning performance of absorbent structures, the following absorbent structures were prepared.

Southern soft wood slash pine fibers were dry mixed with an acrylic acid grafted starch hydrogel having a weight average particle size of about 250 microns ("Sanwet IM 1000", from Sanyo Co., Ltd., Japan) in fiber:hydrogel ratios of 100:0 (no hydrogel), 95:5, 90:10, 85:15, and 80:20. Webs having dimensions of 41×30 cm, and having a basis weight of 390 g/m^2, were prepared in a batch type air laying equipment. The webs were compressed to a dry density of 0.3 g/cm^3, using a flat hydraulic press, corresponding to a thickness of 1.3 mm.

Samples of these webs were subjected to the above-described partitioning test. The following results were obtained:

TABLE I

Partitioning performance of absorbent structures as a function of fiber:hydrogel ratio.

Fiber:Hydrogel Ratio	Loading (g/g) at Reference = 2.0 g/g	Loading (g/g) at Reference = 4.5 g/g
100:0	2.0	3.6
95:5	2.4	4.5
90:10	3.4	5.9
85:15	3.7	6.5
80:20	4.0	7.2

TABLE II

Absorption/desorption data[1] as a function of fiber:hydrogel ratio

Fiber:Hydrogel Ratio	25 cm Absorption	0 cm Void	25 cm Desorption
100:0	2.5	3.0	2.9
95:5	2.9	3.8	3.5
90:10	3.8	4.9	4.5
85:15	4.3	5.9	5.3
80:20	4.8	6.2	5.8

[1]in ml/g, after 10 min. equilibration time

The data demonstrate the dramatic increase in absorption capacities over a wide range of conditions which is obtained by the absorbent structures of the present invention, as compared to all-fiber structures of the same density.

EXAMPLE II

For comparison, absorbent structures were prepared, using the wet-laying process described in U.S. Pat. No. 4,354,901 (issued Oct. 19, 1982 to Kopolow) as follows:

A mixture of southern slash pine wood pulp fibers and an acrylic acid grafted starch hydrogel material (Sanwet IM 1000, from Sanyo Co., Ltd., Japan) (fiber:hydrogel ratio=80:20) was slurried in water at a consistency of 0.7%. A web was formed by straining the slurry on a wire mesh screen. The amount of slurry was such as to result in a basis weight of 0.034 g/cm^2. The web was dried in an oven at 100° C. The density of the dried web was about 0.2 g/cm^3. The web was then compressed in a hydraulic press to a density of 0.38 g/cm^3. The resulting structure was stiff and board-like.

The absorption performance of this sample was determined with the above-described partitioning test. The results are compared with those obtained with an air-laid structure prepared according to the process of the present invention. (Table III)

TABLE III

Partitioning performance of absorbent structures as affected by the process of making.

Fiber:Hydrogel Ratio[1]	Process	Loading (g/g) at Ref. = 2.0 g/g	Loading (g/g) at Ref. = 4.5 g/g
80:20	Air-laying[2]	4.0	7.2
80:20	Wet-laying[3]	3.4	4.5

[1]density of both structures was 0.3 g/cm^2
[2]according to the process of the present invention
[3]process as described in U.S. Pat. No. 4,354,901

The data demonstrate that the process of the present invention results in absorbent structures having absorbent properties which are far superior to those made by a wet-laying process.

EXAMPLE III

The following structures were prepared using the above-described air-laying technique: an all-fiber (southern slash pine) web, density 0.1 g/cm^3 (sample A); an all-fiber (southern slash pine) web, density 0.3 g/cm^3 (sample B); a fiber (southern slash pine)/hydrogel structure (fiber:hydrogel ratio=80:20), density 0.3 g/cm^3 (sample C). The hydrogel was the same as used in Examples I and II. All structures were soft and flexible.

The partitioning performance of these samples was determined using the above described partitioning test, except that equilibration times were one minute.

TABLE IV

Partitioning Performance of Various Absorbent Structures

Sample #	Loading (g/g) at Reference = 2.0 g/g	Loading (g/g) at Reference = 4.5 g/g
A	1.1	4.4
B	2.1	3.9
C*	3.4	7.1

*structure according to the present invention

The partitioning data illustrate that densifying an all-fiber structure (A-B) results in a higher partitioning capacity at low loading (due to better wicking), but a lower capacity at high loading (due to reduce void volume). An 80:20 fiber:hydrogel mixture at high density (0.3 g/cm^3, sample C) possesses vastly superior partitioning properties, both at low and at high loadings.

EXAMPLE IV

Absorbent structures containing different types of hydrogel were made by in-line metering of dry hydrogel particles into a flow of southern softwood slash pine fibers. All hydrogel samples had a weight average particle size in the range of from 100 microns to 1 mm. The mixture were formed into sheets, basis weight of about 0.035 g/cm^2, on a wire screen. The sheets were compressed to a dry density of 0.3 g/cm^3.

The partitioning performance of each sheet was tested with the above-described partitioning test. The results are collected in Table V.

TABLE V

Type of Hydrogel	Fiber:Hydrogel Ratio	Loading at Ref. = 2.0 g/g	Loading at Ref. = 4.5 g/g
None (control)	100:0	2.05	3.60
Starch, acrylonitrile[1]	81.2:18.8	3.45	5.35
Starch, acrylonitrile[2]	84.6:15.4	2.30	5.40
Polyacrylate[3]	75.0:25.0	5.75	8.65
Polyacrylate[3]	80.8:19.2	5.10	8.10
Starch, acrylonitrile[4]	82.7:17.3	4.25	6.10
Starch, acrylonitrile[4]	78.7:21.3	4.25	6.10
Starch, acrylonitrile[5]	82.6:17.4	4.00	5.40
Cellulose, carboxyl[6]	86.0:14.0	2.95	5.14
Cellulose, carboxyl[6]	77.9:22.1	3.20	5.40
Starch, carboxyl[7]	82.1:17.9	2.20	4.40
Starch, acrylic acid[8]	80.1:19.9	3.55	7.00
Starch, acrylic acid[8]	77.7:22.3	4.40	7.40
Isobutylene/ maleic anhydride copolymer[9]	77.6:22.4	4.25	7.75
Isobutylene/ maleic anhydride copolymer[9]	80.0:20.0	4.25	7.45

[1]A-100, from Grain Processing
[2]A-200, from Grain Processing
[3]J-550, from Grain Processing
[4]SGP 147, from Henkel, U.S.A.
[5]SGP 502SB, from Henkel, U.S.A.
[6]Akucell 3019, from Enka, Germany
[7]Foxorb 15, from Avebe, France
[8]Sanwet IM 1000, from Sanyo, Japan
[9]KI Gel 201, from Kuraray, Japan

As the results indicate, the presence of hydrogel particles in a densified hydrophilic fibrous web results in a significant increase in partitioning capacity, both at low load and at high load conditions.

Similar structures are prepared, wherein the southern softwood Kraft pulp fibers are replaced with hardwood Kraft pulp fibers; chemo-thermo mechanical softwood fibers; eucalyptus Kraft pulp fibers; cotton fibers; and polyester fibers. Substantially similar results are obtained.

EXAMPLE V

Absorbent structures were made by the batch-type process described in Example I. Southern softwood Kraft pulp fibers were used in admixture with an acrylic acid grafted starch hydrogel ("Sanwet IM 1000", from Sanyo Co., Ltd., Japan). This type of hydrogel has a saturation capacity for "synthetic urine" of about 25×.

Samples of various fiber/hydrogel ratios were prepared. The kinetics of synthetic urine absorption of these samples was studied in the absorption/desorption apparatus described hereinabove. The synthetic urine used in this test was a solution of 1% NaCl, 0.06% $MgCl_2.6H_2O$ and 0.03% $CaCl_2.2H_2O$ in distilled water; the surface tension of the solution was adjusted to 45 dynes/cm with about 0.0025% of an octyl phenoxy polyethoxy ethanol surfactant (Triton X-100, from Rohm and Haas Co.). All absorbent structures had a density of 0.3 g/cm^3 and a basis weight of about 0.04 g/cm^2. All absorption kinetics were measured under a confining pressure of 1 psi (about 70×10^3N/m^2), which closely approaches real-life conditions for use in diapers.

TABLE VI

Absorption kinetics; hydrostatic pressure −25 cm; absorption mode

Time (min.)	Absorption (ml/g) Fiber/hydrogel ratio (g/g)				
	100:0	88:12	73:27	48:52	34:66
5	2.8	3.8	4.9	3.8	2.7

TABLE VI-continued

Absorption kinetics; hydrostatic pressure −25 cm; absorption mode					
Time (min.)	Absorption (ml/g) Fiber/hydrogel ratio (g/g)				
10	2.8	4.2	5.8	4.6	3.2
30	2.8	4.4	6.4	5.9	4.5
60	—	4.5	6.6	7.0	5.7
360	—	4.6	7.0	9.8	9.1
720	—	—	7.2	11.0	10.6

The data indicate that the equilibrium absorption capacity increases with increasing amounts of hydrogel. The data also demonstrate, however, that the rate at which the equilibrium absorption capacity is approached becomes progressively slower with increasing amounts of hydrogel.

The optimum fiber/hydrogel ratio for this specific fiber-hydrogel system under these testing conditions appears to be around 75:25.

A similar picture is obtained with 0 cm-void volume absorption kinetics, but there are interesting differences (Table VII). Since under these test conditions the wicking properties are less important, the relative performance of the absorbent structures is to a larger extent determined by the equilibrium absorption capacities of these structures. Still, a structure which has very poor absorption kinetics (i.e., fiber/hydrogel ratio of 40:60) is deficient at times 60 min. as compared to 61:39 and 53:47 fiber/hydrogel samples even under 0 cm hydrostatic pressure conditions.

TABLE VII

Absorption kinetics; hydrostatic pressure 0 cm						
Time (min.)	Absorption (ml/g) Fiber/Hydrogel Ratio (g/g)					
	100:0	88:12	78:22	61:39	53:47	40:60
5	4.2	5.9	6.8	7.7	7.5	6.6
10	4.2	6.3	7.5	8.8	8.6	7.6
30	4.2	6.5	8.3	10.2	10.0	9.3
60	—	6.6	8.5	10.7	10.7	10.5
360	—	6.8	8.9	11.7	12.1	13.8

It is expected that, when similar samples are prepared with southern softwood Kraft pulp fibers and a hydrogel which has a saturation capacity for "synthetic urine" of about 10×, the absorption capacities will be lower for each fiber/hydrogel ratio than those given in Table VII. However, for these mixtures, a fiber/hydrogel ratio of 40:60 is expected to perform better than a fiber/hydrogel ratio of 50:50 at 5 and 10 min. equilibration times, contrary to the picture obtained with the above hydrogel having a saturation capacity of 25×.

EXAMPLE VI

Absorbent structures were made according to the process of the present invention, as described in Example I. The fiber/hydrogel weight ratio was 80:20. The Gurley Stiffness values of these structures were determined. For comparison, the Gurley Stiffness values of structures made according to the wet-laying process described in U.S. Pat. No. 4,354,901 (see Example II) were determined before and after densification. (Table VIII)

TABLE VIII

Sample	Density (g/cm^3)	Basis Weight (g/cm^2)	Gurley Stiffness (g)
Wet-laid	0.1	0.037	24.4
Wet-laid	0.1	0.037	27.2
Wet-laid	0.3	0.033	5.4
Wet-laid	0.3	0.033	3.8
Air-laid	0.3	0.032	0.24
Air-laid	0.3	0.032	0.25
Air-laid	0.3	0.035	0.64
Air-laid	0.3	0.035	0.56

The data confirm that the Gurley Stiffness value of a wet-laid structure, which is initially very high, may be reduced by compressing the structure to a higher density, as is disclosed in U.S. Pat. No. 4,354,901. The data further show that the Gurley Stiffness values of the air-laid structures of the present invention are an order of magnitude lower than those of compressed wet-laid structures, and up to 2 orders of magnitude lower than those of uncompressed wet-laid structures.

EXAMPLE VII

A disposable diaper utilizing an absorbent structure according to this invention was prepared as follows:

An absorbent structure prepared as in Example I was calendered to a caliper of about 0.1 cm and a density of about 0.3 g/cm^3 as measured under a confining pressure of 0.1 PSI (about $7\times10^3 N/m^2$). The web was cut into pads of 12 in.×16 in. (about 30×40 cm). The pads were enveloped in wet strength tissue paper having a basis weight of about 12 pounds per 3,000 square feet (about 20 g/m^2), a dry tensile strength of about 700 g/inch in the machine direction and about 300 g/inch in the cross machine direction.

The enveloped pad was glued onto a 13 in.×17 in. (about 33 cm×43 cm) backsheet of embossed polyethylene film having a melt index of about 3 and a density of about 0.92 g/cm^3. The ends of the backsheet were folded over the enveloped pad and attached with glue. Finally, the absorbent pad was covered with a topsheet of a hydrophobic but water and urine pervious material. (Webline No. F 6211 from the Kendall Co. of Walpole, Mass., comprised of a non-woven rayon bonded with an acrylic latex).

The diapers had superior water and synthetic urine absorption, wicking and containment characteristics.

EXAMPLE VIII

Sanitary napkins employing an absorbent structure pursuant to this invention are prepared as follows:

An absorbent structure, prepared as in Example I, is calendered to a caliper of about 0.07 cm and a density of about 0.4 g/cm^3 as measured under a confining pressure of 0.1 PSI (about $7\times10^3 N/m^2$). The web is cut into a pad of 8 in.×2 in. (about 20 cm×5 cm) with tapered ends. On top of this pad is placed a second pad (rectangular) of 5 in.×2 in. (about 13 cm×5 cm). The combined pad structure is placed against a waterproof backing sheet (8 in.×2 in., tapered) of embossed hard polyethylene having an embossed caliper of 2.3 mils. The structure is covered with a top sheet of non-woven, 3 denier needle punched polyester fabric having a density of about 0.03 g/cm^3 and a caliper of about 2.3 mm. The thus covered structure is placed on a 9 in.×3 in. (about 23 cm×7.5 cm) bottom sheet of hydrophobic, spinbonded non-woven polyester having a measured weight of about 15 g/m^2. The bottom sheet is prefolded upwardly by means of heat and pressure which bonds the

superposed sheets together. The resulting absorbent structure is useful as a sanitary napkin and has superior properties of absorption and containment of menses exudate.

EXAMPLE IX

Diapers containing the absorbent structures of the present invention were made as described in Example VII. Control diapers of the same design were made, using wood pulp fiber webs of 0.1 g/cm^3 density instead of the absorbent structures of 0.3 g/cm^3 density.

The diapers were worn by normal infants. The infants were allowed to play in a nursery school setting during the test. The diapers were left on the infants until leakage occurred. In order to speed up the test, the diapers were pre-loaded with a predetermined amount of synthetic urine.

After leakage occurred, the diapers were taken off and weighed to determine the amount of absorbed fluid. The loading X, defined as the amount of fluid (in grams) absorbed at the point that failure occurred per gram of absorbent material, was calculated. The results are presented in Table IX.

The absorbent core of conventional diapers (samples A, G and I) contain about 5 times their own weight of fluid at the point of leakage. The absorbent structures of the present invention contain from 8.0 to 12.7 times their own weight of fluid at the point where leakage occurs. The data further show that the present invention makes it possible to reduce the volume of a diaper core by a factor 7 (as compared to conventional airfelt diaper cores) while maintaining the absorption capacity of the diaper (compare sample J with samples A, G and I).

EXAMPLE XI

Diapers were prepared as described in U.S. Pat. No. 3,860,003, Buell, issued Jan. 14, 1975, incorporated herein by reference. The hourglass-shaped softwood pulp cores had the following dimensions: length: 15.5 in. (about 40 cm), width at the ears: 10.5 in. (about 27 cm), and width in the center: 3.75 in. (about 9.5 cm).

Absorbent structures of the present invention were made with softwood fibers and acrylic acid grafted starch hydrogel having a weight average particle size of about 25 microns ("Sanwet 1M 1000", from Sanyo Co., Japan) in a fiber:hydrogel ratio of 85:15, using the process of Example I. The absorbent structures had a basis weight of 0.12 g/in. (0.019 g/cm^2) and a caliper of 0.03 in. (0.076 cm), which corresponds to a density of 0.25 g/cm^3. The structures were covered with a sheet of envelope tissue, and cut to a size of 3.5 in.×15.5 in. (about 9×40 cm). The structures were inserted lengthwise into the above-described diapers, in between the hourglass-shaped core and the polyethylene backing sheet, the envelope tissue against the hourglass-shaped core.

Additional diapers were prepared by the same method, except that the dimensions of the absorbent structure insert were 2.25×15.5 in. (about 6×40 cm).

The inserts greatly increased the absorbent capacity for urine of the diapers.

EXAMPLE XII

A soft wood fiber drylap as obtained from a conventional paper making process was sprayed with a 10% solution of a quaternary ammonium compound of the formula

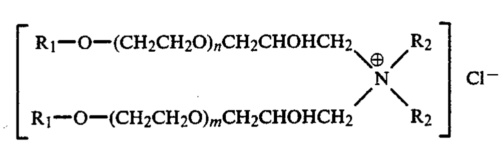
TABLE IX

SAMPLE	A	B	C	D	E	F	G	H	I	J
Absorbent Core (g)	(35.6)	(25.0)	(25.0)	(25.0)	(18.0)	(21.0)	(35.6)	(18.0)	(35.6)	(15.0)
Fiber (g)	34.9	19.7	20.6	19.8	14.8	17.7	35.6	15.3	35.6	12.3
Hydrogel (g)	—	4.9	4.5	4.3	3.3	3.1	—	3.3	—	2.7
Tissue (g)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Total absorbent mat.	40.9	30.6	31.1	30.1	24.1	26.8	41.6	24.6	41.6	21.0
Fiber/hydrogel ratio	—	80/20	82/18	82/18	82/18	85/15	—	82/18	—	82/18
Grams of fluid to grade 3 leakage	194	238	263	208	245	244	179	230	181	183
Total Abs. X to leak	4.7	7.8	8.4	6.9	10.2	9.1	4.3	9.4	4.4	8.7
Core (less tissue) X to failure (g/g)	5.1	9.0	9.9	8.0	12.7	11.0	4.6	11.6	4.7	11.2
Core thickness (mm)	2.9	0.7	0.7	0.7	0.5	0.6	2.9	0.5	2.9	0.4
Core basis weight (mg/cm^2)	29	20	20	20	15	17	29	15	29	12

Alternatively, one may reduce the bulk of the diaper core by less than a factor 7, (e.g. by a factor 4, samples B, C and D; by a factor 5; sample F; or by a factor 6, samples E and H) and yet achieve a substantial gain in absorbent capacity as compared to conventional disposable diapers.

EXAMPLE X

A diaper is prepared as described in U.S. Pat. No. 3,860,003, Buell, issued Jan. 14, 1975, incorporated herein by reference, except that, in addition to the absorbent body dislcosed therein (e.g., made from air-laid wood pulp) there is inserted between said absorbent body and the backsheet an hourglass-shaped absorbent structure of the present invention. The absorbent structure is made as described in Example I. The basis weight is 0.035 g/cm^2; the density is 0.3 g/cm^3, resulting in a thickness of 1.17 mm.



wherein n and m are integers from 2 to 10, R$_1$ is alkylaryl, and R$_2$ is alkyl having from 1 to 6 carbon atoms (Berocell 579, from Berol Chemicals, Inc., Metarie, LA).

The drylap was sprayed at a rate of 10 g solution per kg dry fiber, corresponding to 0.1% quaternary ammonium compound on the fiber. The drylap was then disintegrated, and the fibers mixed with an acrylic acid grafted starch hydrogel having a weight average particle size of about 250 microns ("Sanwet 1M 1000", from

Sanyo Co., Ltd., Japan) in a fiber:hydrogel ratio of 80:20.

The fiber:hydrogel mixture was formed into an air-laid web having a basis weight of 0.13 g/in^2 (about 200 g/m^2). The web was calendered to a density of about 0.2 g/cm^2, corresponding to a thickness of about 0.038 in (about 2 mm). The absorbent structure thus obtained had excellent absorbent properties and softness. Similar structures are prepared, replacing the quaternary ammonium compound with nonionic and anionic softening agents. Structures having substantially similar properties are obtained.

The web containing the quaternary ammonium compound was cut into pads of $11\frac{7}{8}\times 16$ in (about 30×41 cm). The pads were used in the manufacture of disposable diapers as described in Example VII.

What is claimed is:

1. A flexible, substantially unbonded, absorbent structure comprising an air-laid, substantially dry mixture of hydrophilic fibers and discrete particles of a water-insoluble, cross-linked polymeric hydrogel, in a fiber/hydrogel weight ratio from about 30:70 to about 98:2; said absorbent structure having a density of from about 0.15 to about 1 g/cm^3, a moisture content of less than about 10% by weight of the dry absorbent structure and a Gurley Stiffness value of less than 2 grams.

2. An absorbent structure according to claim **1**, having a fiber/hydrogel weight ratio of from about 50:50 to about 95:5.

3. An absorbent structure according to claim **1**, having a fiber/hydrogel weight ratio of from about 75:25 to about 90:10.

4. An absorbent structure according to claim **1**, having a density of from about 0.15 to about 0.6 g/cm^3.

5. An absorbent structure according to claim **1**, having a density of from about 0.25 to about 0.44g/cm^3.

6. An absorbent structure according to claim **1** wherein the hydrophilic fibers are wood pulp fibers.

7. An absorbent structure according to claim **1**, further comprising from about 0.01% to about 0.5% by weight of the hydrophilic fibers of a quaternary ammonium compound of the formula

$$\left[\begin{array}{l} R_1{-}O{-}(C_2H_4O)_n{-}CH_2{-}CHOH{-}CH_2 \quad\; R_3 \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad \overset{\oplus}{N} \\ R_2{-}O{-}(C_2H_4O)_m{-}CH_2{-}CHOH{-}CH_2 \quad\; R_4 \end{array}\right] X^{\ominus}$$

wherein R_1 and R_2 are hydrocarbyl groups containing from about 8 to about 22 carbon atoms, R_3 and R_4 are alkyl having from 1 to 6 carbon atoms; n and m are integers from 2 to about 10, and X is halogen.

8. An absorbent structure according to claim **1** which the has a Gurley Stiffness value of less than 1 g.

9. An absorbent structure according to claim **1**, wherein the hydrogel particles have an average particle size of from about 30 microns to about 4 mm.

10. An absorbent structure according to claim **1**, wherein the hydrogel particles have an average particle size of from about 50 microns to about 1 mm.

11. A flexible, substantially unbonded, absorbent structure comprising an air-laid, substantially dry mixture of wood pulp fibers and discrete particles of a water-insoluble, cross-linked polymeric hydrogel in a fiber/hydrogel weight ratio of from about 75:25 to about 90:10, said cross-linked polymeric hydrogel being selected from the group consisting of hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylate, co-polymers of isobutylene and maleic anhydride, and mixtures thereof, said particles having an average particle size of from about 50 microns to about 1 mm; said structure having a density of from about 0.15 to about 0.6 g/cm^3 and a Gurley Stiffness value of less than 2 grams.

12. A process for making a continuous, flexible absorbent structure, comprising the following steps:

(a) air-laying into a web a dry mixture of hydrophilic fibers and particles of a water-insoluble, cross-linked polymeric hydrogel, said mixture having a fiber/hydrogel weight ratio of from about 30:70 to about 98:2 and a moisture content of less than about 10% by weight of the mixture; and,

(b) compressing the web to a density of from about 0.15 to about 1 g/cm^3 and a Gurley Stiffness value of less than 2 grams.

13. A process according to claim **12**, whereby the mixture of hydrophilic fibers and hydrogel particles has a fiber/hydrogel weight ratio of from about 50:50 to about 95:5.

14. A process according to claim **12**, whereby the mixture of hydrophilic fibers and hydrogel particles has a fiber/hydrogel weight ratio of from about 75:25 to about 90:10.

15. A process according to claim **12** whereby the web is compressed to a density of from about 0.15 to about 0.6 g/cm^3.

16. A process according to claim **12** whereby the web is compressed to a density of from about 0.25 to about 0.4 g/cm^3.

17. A process according to claim **12**, wherein the hydrophilic fibers are wood pulp fibers.

18. A process according to claim **12**, wherein the cross-linked polymeric hydrogel is selected from the group consisting of hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates, co-polymers of isobutylene and maleic anhydride, and mixtures thereof.

19. A process according to claim **12**, wherein the hydrogel particles have an average particle size of from about 30 microns to about 4 mm.

20. A process according to claim **12** wherein the hydrogel particles have an average particle size of from about 50 microns to about 1 mm.

21. A process for making a flexible, substantially unbonded, absorbent structure, comprising the following steps:

(a) dry mixing of hydrophilic fibers and particles of a water-insoluble, cross-linked polymeric hydrogel in a weight ratio of from about 75:25 to about 90:10, said particles having an average size of from about 50 microns to about 1 mm, and said cross-linked polymeric hydrogel being selected from the group consisting of hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates, copolymers of isobutylene and maleic anhydride, and mixtures thereof to form a fiber/hydrogel mixture having a moisture content of less than 10% by weight;

(b) air-laying of the mixture obtained in step (a) into a web; and

(c) compressing the web into a density of from about 0.15 to about 0.6 g/cm^3 and a Gurley Stiffness value of less than 2 grams.

22. An absorbent structure made according to the process of claim **12**.

23. An absorbent product comprising the absorbent structure of claim **1**.

24. A disposable diaper, comprising:

(a) a liquid impervious backing sheet;

(b) a hydrophobic top sheet;

(c) an absorbent structure according to claim **1**, said structure being placed between the backing sheet and the top sheet.

25. A disposable diaper, comprising:

(a) a liquid impervious backing sheet;

(b) a hydrophobic topsheet; and

(c) an absorbent structure according to claim **7**, said structure being placed between the backing sheet and the topsheet.

26. A disposable diaper according to claim **24**, wherein the absorbent structure has a basis weight of from about 0.01 to about 0.05 g/cm^2.

27. A disposable diaper according to claim **24** wherein the absorbent structure is wrapped in envelope tissue.

28. A disposable diaper according to claim **27** wherein the absorbent structure has a thickness of from about 0.3 mm to about 2 mm.

29. A disposable diaper according to claim **27** wherein the absorbent structure has a thickness of from about 0.5 mm to about 1 mm.

30. A disposable diaper according to claim **24** wherein the absorbent structure is hourglass-shaped.

31. A disposable diaper according to claim **24** further comprising a wood pulp fiber absorbent core which is placed between the hydrophobic top sheet (b) and the absorbent structure (c).

32. A disposable diaper according to claim **31** wherein the wood pulp fiber absorbent core is hourglass shaped and the absorbent structure (c) is rectangular.

33. A sanitary napkin comprising:

(a) a liquid impervious backing sheet;

(b) a hydrophobic top sheet;

(c) an absorbent structure according to claim **1**, said structure being placed between the backing sheet and the top sheet.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,610,678

DATED : September 9, 1986

INVENTOR(S) : Paul T. Weisman and Stephen A. Goldman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover page, the assignee should be identified as follows:
--Assignee: The Procter & Gamble Company, Cincinnati, Ohio--.

On the cover page, in the "Related U.S. Application Data" section;
delete "Ser. No. 437,846" and insert therefor --Ser. No. 473,846--.

Column 1, line 7; delete "Ser. No. 437,846" and insert therefor
--Ser. No. 473,846--

Column 19, line 36, in Claim 5;
delete "0.44 g/cm^3" and insert therefor --0.4 g/cm^3--.

Column 19, line 55, in Claim 8;
delete "the".

Column 22, line 22; add the following additional Claim 34;

--34. An absorbent structure according to Claim 1 wherein the water-insoluble hydrogel is a cross-linked polymer selected from the group consisting of hydrolyzed acrylonitrile grafted starch, acrylic acid

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,610,678

DATED : September 9, 1986

INVENTOR(S) : Paul T. Weisman and Stephen A. Goldman

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

grafted starch, polyacrylates, copolymers of isobutylene and maleic anhydride, and mixtures thereof.--.

Signed and Sealed this

Second Day of August, 1988

Attest:

DONALD J. QUIGG

Attesting Officer

Commissioner of Patents and Trademarks

United States Patent [19]
Weisman et al.
[11] Patent Number: 4,673,402
[45] Date of Patent: Jun. 16, 1987

[54] **ABSORBENT ARTICLES WITH DUAL-LAYERED CORES**

[75] Inventors: **Paul T. Weisman; Dawn I. Houghton**, both of Fairfield, Ohio; **Dale A. Gellert**, Aurora, Ind.

[73] Assignee: **The Procter & Gamble Company**, Cincinnati, Ohio

[21] Appl. No.: **895,526**

[22] Filed: **Aug. 11, 1986**

Related U.S. Application Data

[63] Continuation of Ser. No. 734,426, May 15, 1985, abandoned.

[51] **Int. Cl.**^{4} **A61F 13/16**
[52] **U.S. Cl.** **604/368**; 604/378
[58] **Field of Search** 604/358, 359, 367, 368, 604/378, 379, 385.1, 394, 396; 428/281, 286, 287, 289

[56] **References Cited**

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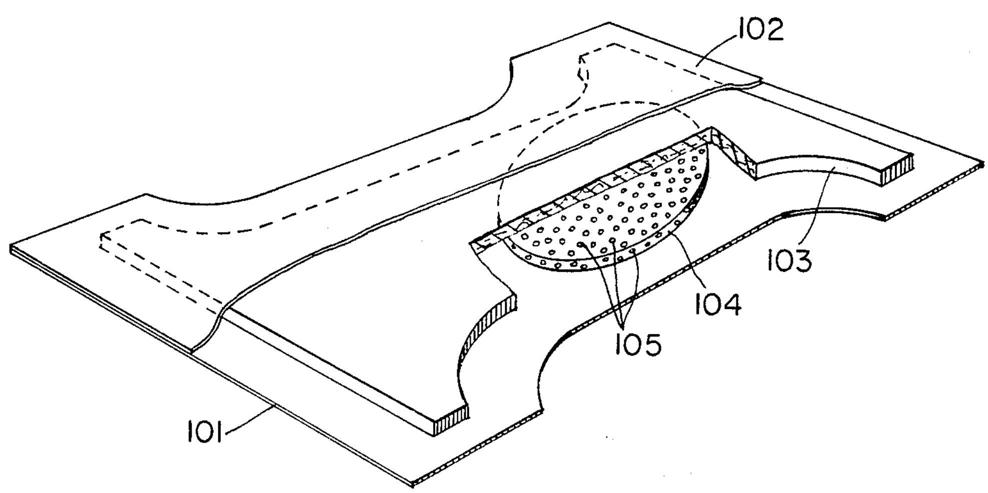
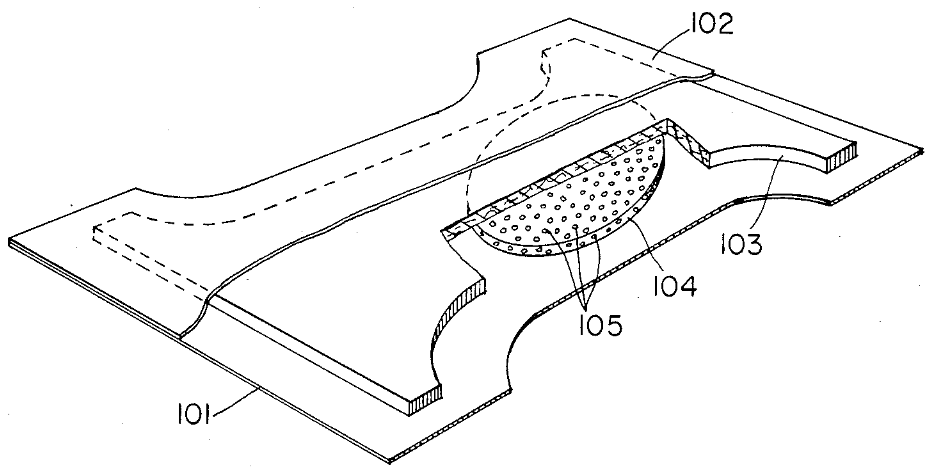
Primary Examiner—John D. Yasko
Attorney, Agent, or Firm—George W. Allen; Steven J. Goldstein; Richard C. Witte

[57] **ABSTRACT**

The present invention provides absorbent articles, such as disposable diapers, which utilize substantially water-insoluble hydrogel material to enhance the absorbent capacity of such articles. In these articles, the hydrogel material, combined in particulate form with hydrophilic fiber material, is primarily placed in a lower fluid storage layer of the absorbent core of the article. Such a fluid storage lower layer of the absorbent core is placed underneath an upper, preferably larger, fluid acquisition/distribution layer containing little or no hydrogel. This lower fluid storage layer is positioned in such a manner that at least about 75% of the hydrogel in the lower layer is found in the front two-thirds of the absorbent article and such that at least about 55% of the hydrogel in the lower layer is found in the front half of the absorbent article. Absorbent articles of this type make especially effective and efficient use of the hydrogel material and may also provide a diaper rash control benefit. Absorbent cores of the type utilized in such articles are also disclosed.

21 Claims, 1 Drawing Figure

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ABSORBENT ARTICLES WITH DUAL-LAYERED CORES

This is a continuation of application Ser. No. 734,426, filed on May 15, 1985, now abandoned.

FIELD OF THE INVENTION

This invention relates to absorbent articles using both hydrophilic fiber material and discrete particles of substantially water-insoluble hydrogel as absorbents. Absorbent articles of this type include disposable diapers, adult incontinence pads, sanitary napkins and the like.

BACKGROUND OF THE INVENTION

Water-insoluble hydrogels are polymeric materials which are c le of absorbing large quantities of fluids such as water and body wastes and which are further capable of retaining such absorbed fluids under moderate pressures. These absorption characteristics of water-insoluble hydrogels make such materials especially useful for incorporation into absorbent articles such as disposable diapers. Harper et al.; U.S. Pat. No. 3,669,103; Issued June 13, 1972 and Harmon; U.S Pat. No. 3,670,731; Issued June 20, 1972, for example, both disclose the use of hydrogel, i.e., "hydrocolloid," materials in absorbent products.

The effectiveness of fluid-absorbing hydrogel materials in disposable absorbent articles can be quite dependent upon the form, position and/or manner in which the hydrogel material is incorporated into the absorbent article. In some cases, for example, the effectiveness of hydrogel fluid absorption in absorbent articles can be adversely affected by a phenomenon called gel blocking. The term gel blocking describes a situation that occurs when a hydrogel particle, film, fiber, composite, etc. is wetted. Upon wetting, the surface of the hydrogel material swells and inhibits liquid transmission to the interior of the absorbent material. Wetting of the interior subsequently takes place via a very slow diffusion process. In practical terms, this means that absorption of fluid by the article is much slower than discharge of fluid to be absorbed, and failure of a diaper or sanitary napkin or other absorbent article may take place well before the hydrogel material in the absorbent article is fully saturated.

A number of prior art attempts have been made to improve the effectiveness of hydrogel materials in absorbent articles by minimizing gel blocking tendency. Thus, for Procter & Gamble; European Patent Application EP-A-No. 122,042; Published Oct. 17, 1984 discloses absorbent structures wherein hydrogel particles are dispersed in an air-laid web of hydrophilic fibers compressed to a particular density. Mesek et al.; U.S. Pat. No. 4,235,237; Issued Nov. 25, 1980 discloses an open absorbent network having particles of water-insoluble, water-swellable material spaced from each other within the network. Mazurak et al; U.S. Pat. No. 4,381,782; Issued May 3, 1983 discloses absorbent fibrous structures containing mixtures of hydrogel particles and surfactant-treated filler materials. Colgate Palmolive; U.K. Patent Specification No. 2,132,897A; Published July 18, 1984 discloses disposable absorbent articles containing a pad assembly having one or more surfaces coated with absorbent polymer in patterns designed to prevent gel blocking.

Other prior art attempts to improve the effectiveness of hydrogel materials in absorbent structures have involved particular arrangements for positioning hydrogel within the absorbent structure in discrete zones such as layers or pockets. The aforementioned EP-A-No. 122,042, for example, indicates that a hydrogel-containing absorbent structure can be positioned as a lower layer in a disposable absorbent product underneath an upper layer containing only hydrophilic fiber material. Mesek et al.; U.S. Pat. No. 4,102,340; Issued July 25, 1978 discloses an absorbent article having a hydrogel-containing batt positioned underneath a densified layer of fibrous material. Elias; U.S. Pat. No. 4,381,783; Issued May 3, 1983 discloses an absorbent article which includes an absorbent layer containing pockets of an admixture of hydrogel particles and discrete introfying particles. Holtman et al., U.S. Pat. No. 4,333,426; Issued June 8, 1982 and Holtman; U.S. Pat. No. 4,333,463; Issued June 8, 1982 both disclose absorbent structures containing reservoirs of superabsorbent particles positioned near one end of the structure at the void zone of the wearer. Personal Products Co.; European Patent Application EP-A-No. 108,637; Published May 16, 1984 describes thin absorbent products having a superabsorbent-containing absorbing layer and a wicking layer. Willington; U.K. Patent Specification No. 1,406,615; Published Mar. 15, 1973 discloses an absorbent pad having a urine-gelling agent incorporated only in the part of the pad "where it will be most effective."

Notwithstanding the various prior art attempts to improve the effectiveness of hydrogel materials in absorbent structures and products, there is a continuing need to identify hydrogel-containing absorbent articles wherein the hydrogel material is especially effective and efficient in performing its intended function of holding discharged body fluids without interfering with the acquisition and distribution of body fluids by and within the article. Hydrogel materials are generally significantly more expensive than readily available hydrophilic fiber materials (e.g. cellulose fibers). Accordingly it would be advantageous to provide articles wherein either absorbent capacity of the hydrogel-containing article can be improved or wherein a given absorbent capacity of an article can be maintained while reducing the amount of relatively expensive hydrogel material used. It would also be advantageous to provide articles wherein the fluid-storing hydrogel material does not adversely affect the ability of the absorbent article to quickly acquire discharged body fluids. It is therefore a primary objective of the present invention to provide absorbent articles which are especially effective and efficient in their use of hydrogel absorbent materials.

Another potential advantage which can be provided by certain hydrogel-containing disposable absorbent articles relates to the prevention or reduction of diaper rash. Diaper rash is a common form of irritation and inflammation of those parts of an infant's skin normally covered by a diaper. This condition is also referred to as diaper dermatitis, napkin dermatitis, napkin rash or nappy rash.

It is generally accepted that true "diaper rash" or "diaper dermatitis" is a condition which is commonly, in its most simple stages, a contact irritant dermatitis. The irritation of simple diaper rash results from extended contact of the skin with body waste. Diapers which catch and hold body waste in contact with the skin for long periods of time thus cause and/or aggravate diaper rash.

It has now been discovered that a primary cause of diaper rash is a particular set of conditions which arises as a result of prolonged contact of skin with mixtures of feces and urine. Activity of proteolytic and lipolytic fecal enzymes present in such a mixture is believed to be a major factor in producing skin irritation. Urine in contact with enzymes from feces can also result in production of ammonia which raises skin pH. This rise in skin pH, for example to levels of 6.0 and above, in turn increases that fecal proteolytic and lipolytic enzymatic activity which produces diaper rash.

The foregoing diaper rash model suggests that effective diaper rash control may be achieved by preventing mixtures of urine and feces from contacting diapered skin for any significant length of time. Prior art disposable diaper structures have not in general been designed to eliminate mixing of discharged urine and feces. It is, accordingly, a secondary objective of the present invention to provide absorbent articles such as diapers which hold discharged urine and feces in separate locations within the absorbent article and which might thereby prevent or reduce diaper rash caused by skin contact with urine-feces mixtures.

SUMMARY OF THE INVENTION

The present invention provides an absorbent article such as a diaper or incontinence pad which is suitable for absorbing body fluids in an especially effective and efficient manner and which may also prevent or reduce the incidence of diaper rash. Such an absorbent article comprises an elongated liquid impervious backing sheet, a relatively hydrophobic, liquid pervious topsheet and a layered, absorbent core positioned between the backing sheet and the topsheet.

The absorbent core comprises both an upper fluid acquisition/distribution layer which is preferably elongated and which consists essentially of hydrophilic fiber material and a lower fluid storage layer which consists essentially of a substantially uniform combination of hydrophilic fiber material and discrete particles of substantially water-insoluble hydrogel material.

The upper fluid acquisition layer has a density of from about 0.05 to 0.25 g/cm^3 and can optionally contain up to about 8% by weight of the upper layer of particles of substantially water-insoluble hydrogel material. The lower fluid storage layer has a density of from about 0.06 to 0.3 g/cm^3 and must contain from about 9% to 60% by weight of the lower layer of the hydrogel particles.

The lower fluid storage layer of the absorbent core has a top surface area which is from about 0.25 to 1.00 times the top surface area of the upper fluid acquisition/distribution layer. The lower fluid storage layer is further positioned relative to the upper fluid acquisition/distribution layer in a manner such that at least about 75% of the hydrogel material in the lower layer is found within the front two-thirds section of the article and such that at least about 55% of the total hydrogel material in the lower layer is found within the front half section of the article.

The present invention also relates to dual-layer absorbent cores, per se, of the type heretofore described, which can be employed in absorbent articles. Cores of the type utilized herein in absorbent articles, in addition to providing especially efficient and effective use of hydrogel absorbents, are also less likely to tear under the stress of wearing and loading.

BRIEF DESCRIPTION OF THE DRAWING

The drawing represents a cut-away view of a diaper structure having a dual-layer absorbent core.

DETAILED DESCRIPTION OF THE INVENTION

The absorbent articles of the present invention can be manufactured in the configuration of wearable disposable products which are capable of absorbing significant quantities of water and body waste fluids such as urine, feces and menses. Thus such articles, for example, may be prepared in the form of disposable diapers, adult incontinence pads, sanitary napkins and the like.

The absorbent articles herein generally comprise three basic structural components. One such component is an elongated, liquid impervious backing sheet. On top of this backing sheet is placed an absorbent core which itself comprises two or more distinct layers. On top of this absorbent core is placed a relatively hydrophobic, water pervious topsheet. The topsheet is the element of the article which is placed next to the skin of the wearer.

Especially preferred absorbent articles of this invention are disposable diapers. Articles in the form of disposable diapers are fully described in Duncan and Baker, U.S. Pat. No. Re. 26,151, Issued Jan. 31, 1967; Duncan, U.S. Pat. No. 3,592,194, Issued July 13, 1971; Duncan and Gellert, U.S. Pat. No. 3,489,148, Issued Jan. 13, 1970; and Buell, U.S Pat. No. 3,860,003, Issued Jan. 14,1975; which patents are incorporated herein by reference. A preferred disposable diaper for the purpose of this invention comprises an absorbent core; a topsheet superposed or co-extensive with one face of the core, and a liquid impervious backsheet superposed or co-extensive with the face of the core opposite the face covered by the topsheet. The backsheet most preferably has a width greater than that of the core thereby providing side marginal portions of the backsheet which extend beyond the core. The diaper is preferably constructed in an hourglass configuration.

The elongated backing sheet (or backsheet) of the articles herein can be constructed, for example, from a thin, plastic film of polyethylene, polypropylene, or other flexible moisture impeding material which is substantially water impervious. Polyethylene, having an embossed caliper of approximately 1.5 mils, is especially preferred. For purposes of this invention, the backsheet is elongated if it is of unequal length and width in the unfolded, flat configuration.

The topsheet of the articles herein can be made in part or completely of synthetic fibers such as polyester, polyolefin, rayon, or the like, or of natural fibers such as cotton. The fibers are typically bound together by a thermal binding procedure or by a polymeric binder such as polyacrylate. This sheet is substantially porous and permits a fluid to readily pass therethrough into the underlying dual-layered absorbent core. The topsheet can be made more or less hydrophobic depending upon the choice and treatment of fiber and binder used in the construction thereof. The topsheets used in the articles of the present invention are relatively hydrophobic in comparison with the absorbent core of said articles. Topsheet construction is generally disclosed in Davidson, U.S. Pat. No. 2,905,176, Issued Sept. 22, 1959; Del Guercio, U.S. Pat. No. 3,063,452, Issued Nov. 13, 1962; and Holliday, U.S. Pat. No. 3,113,570, Dec. 10, 1963, which patents are incorporated herein by reference.

Preferred topsheets are constructed from polyester, rayon, rayon/polyester blends or polypropylene.

An absorbent core, which itself comprises two or more distinct layers, and which is preferably flexible, is positioned between the elongated backing sheet and the topsheet to form the absorbent articles herein. This core essentially comprises both an upper fluid acquisition/-distribution layer and a lower fluid storage layer. It should be understood that for purposes of this invention these two types of layers refer merely to the upper and lower zones of the absorbent core and are not necessarily limited to single layers or sheets of material. Thus both the fluid acquisition/distribution layer and the fluid storage layer may actually comprise laminates or combinations of several sheets or webs of the requisite type of materials as hereinafter described. Thus as used herein, the term "layer" includes the terms "layers" and "layered."

One essential element of the absorbent core is an upper fluid acquisition/distribution layer which consists essentially of hydrophilic fiber material. This fluid acquisition/distribution layer serves to quickly collect and temporarily hold discharged body fluid. Since such fluid is discharged in gushes, the upper acquisition/distribution layer must be able to quickly acquire and transport fluid by wicking from the point of initial fluid contact to other parts of the acquisition/distribution layer. In the context of the present invention, it should be noted that the term "fluid" means "liquid."

Various types of hydrophilic fiber material can be used in the upper fluid acquisition/distribution layer of the core. Any type of hydrophilic fiber which is suitable for use in conventional absorbent products is also suitable for use in the upper layer of the core of the present absorbent articles. Specific examples of such fibers include cellulose fibers, rayon, and polyester fibers. Other examples of suitable hydrophilic fibers are hydrophilized hydrophobic fibers, such as surfactant-treated or silica-treated thermoplastic fibers. Also, fibers which do not provide webs of sufficient absorbent capacity to be useful in conventional absorbent structures, but which do provide good wicking properties, are suitable for use in the upper layer of the absorbent core of the present invention. This is so because the primary purpose of the upper layer of the core is to acquire and distribute fluid which has passed through the topsheet. Wicking properties of the fibers in the upper layer are thus of primary importance. For reasons of availability and cost, cellulose fibers, in particular wood pulp fibers, are preferred.

As indicated the primary function of the upper layer of the absorbent core is to receive fluids passing through the relatively hydrophobic, water pervious topsheet and to transport such fluids to other areas of the upper layer and eventually on to the fluid-holding, hydrogel-containing lower fluid storage layer of the core. The upper acquisition/distribution layer of the core can thus be substantially free of hydrogel material. Alternatively, the upper acquisition/distribution layer can contain small amounts of hydrogel material in particle form as hereinafter described. Thus the upper layer can, for example, contain up to about 8%, and preferably no more than about 6%, by weight of the upper layer of hydrogel particles. In some instances, the presence of hydrogel particles in the fluid acquisition/distribution layer can actually serve to maintain the density of the upper layer within the optimum range to promote fluid distribution. The specific type of hydrogel optionally used in the upper layer does not have to be the same as the hydrogel type essentially employed in the lower layer.

The shape, size and character, including capillarity (e.g., density), of the upper fluid acquisition/distribution layer of the articles herein is of some importance in determining the effectiveness of the resulting absorbent articles in absorbing discharged body fluids. As indicated, the upper absorbent layer of the core is preferably elongated. For purposes of this invention, this means that the upper layer, like the backing sheet, is elongated if it is of unequal length and width in the unfolded, flat configuration. The upper layer in the unfolded configuration can be of any desired shape, for example, rectangular, trapezoidal, oval, oblong or hourglass-shaped. The shape of the upper fluid acquisition/-distribution layer of the core will frequently define the general shape of the resulting absorbent article.

The upper fluid acquisition/distribution layer will generally have a density of from about 0.05 to 0.25 g/cm^3. The basis weight of the upper layer of the absorbent core will typically range from about 0.015 to 0.1 g/cm^2. Density values are calculated from basis weight and layer caliper measured on newly unpacked, unfolded and dissected diapers. Caliper is measured under a "gentle" load of 10 grams/cm^2. Density and basis weight values include the weight of hydrogel particles, if present.

In preferred embodiments of the present invention the upper fluid acquisition/distribution layer of the core will be hourglass-shaped and will be of substantially uniform density within the range of from about 0.07 to 0.14 g/cm^3. Preferably, the upper fluid acquisition/distribution layer of the core will have a basis weight ranging from about 0.03 to 0.06 g/cm^2.

The upper layer of the absorbent core can be prepared in any conventional manner suitable for realizing a web of hydrophilic fiber material. Preferably the upper layer is formed by air-laying a stream of fiber material onto a screen until a web of the desired basis weight is formed. Such a web can subsequently be densified if necessary. Alternatively the upper fluid acquisition/distribution layer can comprise several layers of web material or can comprise, for example, a laminate or stack of tissue paper, provided such a layered structure, e.g., laminate, is of the requisite density hereinbefore set forth.

The lower fluid storage layer of the absorbent core of the articles herein consists essentially of a substantially uniform combination of hydrophilic fiber material and particular amounts of discrete particles of substantially water-insoluble, fluid-absorbing hydrogel material. The principal function of the fluid storage layer is to absorb discharged body fluid from the upper acquisition/distribution layer and retain such fluid under the pressures encountered as a result of the wearer's movements. Ideally the fluid storage lower layer will drain the upper layer of much of its aquired fluid load.

The hydrophilic fibers in the lower fluid storage layer can be of the same type as those hereinbefore described for use in the upper fluid acquisition/distribution layer. As in the upper layer, cellulose fibers, and especially wood pulp fibers and wood pulp tissue, are preferred.

In addition to hydrophilic fiber material, the lower fluid storage layer of the absorbent core of the articles herein also essentially contains discrete particles of substantially water-insoluble hydrogel material. Such hydrogel materials are inorganic or organic compounds

capable of absorbing fluids and retaining them under moderate pressures.

Suitable hydrogels can be inorganic materials such as silica gels or organic compounds such as cross-linked polymers. Cross-linking may be by covalent, ionic, vander Waals, or hydrogen bonding. Examples of hydrogel polymers include polyacrylamides, polyvinyl alcohol, ethylene maleic anhydride copolymers, polyvinyl ethers, hydroxypropyl cellulose, carboxymethyl cellulose, polyvinyl morpholinone, polymers and copolymers of vinyl sulfonic acid, polyacrylates, polyacrylamides, polyvinyl pyridine and the like. Other suitable hydrogels are those disclosed in Assarsson et al., U.S. Pat. No. 3,901,236, Issued Aug. 26, 1975, the disclosure of which is incorporated herein by reference. Particularly preferred hydrogel polymers for use in the absorbent core are hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates, and isobutylene maleic anhydride copolymers, or mixtures thereof.

Processes for preparing hydrogels are disclosed in Masuda et al., U.S. Pat. No. 4,076,663, Issued Feb. 28, 1978; in Tsubakimoto et al., U.S. Pat. No. 4,286,082, Issued Aug. 25, 1981; and further in U.S. Pat. Nos. 3,734,876, 3,661,815, 3,670,731, 3,664,343, 3,783,871, and Belgian Patent No. 785,850, the disclosures of which are all incorporated herein by reference.

Hydrogel material optionally found in the upper fluid acquisition/distribution layer and essentially found in the lower fluid storage layer of the absorbent cores herein is used in the form of discrete particles. Hydrogel particles can be of any desired shape, e.g., spherical or semi-spherical, cubic, rod-like, polyhedral, etc. Shapes having a large greatest dimension/smallest dimension ratio, like needles, flakes and fibers, are also contemplated for use herein. Conglomerates of hydrogel particles may also be used.

Although the hydrogel-containing layers are expected to perform well with hydrogel particles having a particle size varying over a wide range, other considerations may preclude the use of very small or very large particles. For reasons of industrial hygiene, average particle sizes smaller than about 30 microns are less desirable. Particles having a smallest dimension larger than about 2 mm may also cause a feeling of grittiness in the absorbent article, which is undesirable from a consumer aesthetics standpoint. Furthermore, rate of fluid absorption is affected by hydrogel particle size. Larger particles have very much reduced rates of absorption. Preferred for use herein are hydrogel particles having an average particle size of from about 50 microns to about 1 mm. "Particle Size" as used herein means the weighted average of the smallest dimension of the individual particles.

The relative amount of hydrophilic fiber material and hydrogel particles used in the lower fluid storage layer of the absorbent cores of the articles herein can be most conveniently expressed in terms of a weight percentage of the lower layer. The lower fluid storage layer of the absorbent cores herein must contain from about 9% to 60%, preferably from about 15% to 40%, by weight of the lower layer of hydrogel material. This concentration of hydrogel material can also be expressed in terms of a weight ratio of hydrogel to fiber. These ratios may range from about 9:91 to about 60:40. For most commercially available hydrogels the optimum hydrogel/fiber ratio is in the range of from about 9:91 to about 50:50. Based on a cost/performance analysis, hydrogel/fiber ratios of from about 20:80 to about 33:67 are preferred for use in the lower fluid storage layer.

The density of the hydrogel-containing lower fluid storage layer of the absorbent core can be of some importance in determining the absorbent properties of the resulting absorbent article. The density of the lower fluid storage layer will generally be in the range of from about 0.06 to about 0.3 g/cms^3, and more preferably within the range of from about 0.09 to about 0.18 g/cm^3. Typically the basis weight of the lower fluid storage layer can range from about 0.02 to 0.12 gm/cm^2. As with the upper layer, density values for the lower layer are calculated from basis weight and layer caliper measured on newly unpacked, unfolded and dissected articles. Caliper is measured under a "gentle" load of 10 grams/cm^2. Density and basis weight values include the weight of the hydrogel particles.

In a preferred embodiment of the present invention, the lower fluid storage layer will comprise an intimate admixture of hydrophilic fiber material and hydrogel particles with the hydrogel particles preferably being substantially uniformly distributed throughout a hydrophilic fiber matrix. Absorbent core lower fluid storage layers of this type can be formed by air-laying a dry mixture of hydrophilic fibers and hydrogel particles and densifying the resulting web. Such a procedure is described more fully in Procter & Gamble; European Patent Publication No. EP-A-No. 122,042; Published Oct. 17, 1984, incorporated herein by reference. As indicated in this reference, the webs formed by this procedure for use as the lower fluid storage layer will preferably comprise substantially unbonded fibers and will preferably have a moisture content of 10% or less.

Alternatively, the substantially uniform combination of hydrophilic fiber material and hydrogel particles used as the fluid storage layer of the core can comprise a laminate of at least two layers of dispersed hydrogel particles, overwrapped with and separated by sheets of hydrophilic fiber material such as tissue paper. Such a laminate structure is more fully described in Kramer, Young and Koch; U.S. Ser. No. 563,339; Filed Dec. 20, 1983, incorporated herein by reference.

It has been discovered that the hydrogel-containing lower fluid storage layer of the absorbent core need not be as large as the upper fluid acquisition/distribution layer of the core and can, in fact, have a top surface area (in the unfolded configuration) which is substantially smaller than the top surface area (unfolded) of the upper layer of the absorbent core. Generally, the top surface area of the lower fluid storage layer will range from 0.25 to 1.0 times that of the upper acquisition/distribution layer. More preferably the top surface area of the lower layer will be only from about 0.25 to 0.75, and most preferably from about 0.3 to 0.5, times that of the upper layer.

In accordance with the present invention, the lower fluid storage layer of the absorbent core must be placed in a specific positional relationship with respect to the backing sheet and/or the upper fluid acquisition/distribution layer in the absorbent article. More particularly, the hydrogel-containing lower fluid storage layer of the core must be positioned generally toward the front of the absorbent article so that hydrogel is most effectively located to drain and hold discharged body fluid from the upper acquisition/distribution layer. For purposes of the present invention, the front of the absorbent articles herein means the end of the absorbent article which is intended to be placed on the front of the wearer. Thus

the lower fluid storage layer is to be placed in the vicinity of the point of discharge of body fluids.

The generally forward positioning of the lower hydrogel-containing fluid storage layer can be defined by specifying the percentage of total lower layer hydrogel which is found forward of particular points along the length of the absorbent article. Thus, in accordance with the present invention, the lower hydrogel-containing fluid storage layer is positioned relative to the upper elongated backing sheet and/or the acquisition/distribution layer such that (1) at least about 75% of the total hydrogel in the lower fluid storage layer is found within the front two-thirds section of the absorbent article, and (2) at least about 55% of the total hydrogel in the lower fluid storage layer is found within the front half section of the absorbent article.

More preferably, the lower fluid storage layer of the core is positioned relative to the elongated backing sheet and/or the upper acquisition/distribution layer such that at least about 90% of the total hydrogel in the lower layer is found in the front two-thirds section and at least about 60% of the total hydrogel in the lower layer is found in the front half section of the absorbent article. As noted, for purposes of the present invention, "sections" of the absorbent article can be defined by reference to top surface areas of the unfolded absorbent article found in front of a given point on the line which defines the length of the absorbent article.

For purposes of determining such lower layer positioning, the length of the absorbent article will be taken as the normal longest longitudinal dimension of the elongated article backing sheet. This normal longest dimension of the elongated backing sheet can be defined with respect to the article as it is applied to the wearer. When worn, the opposing ends of the backing sheet are fastened together so that these joined ends form a circle around the wearer's waist. The normal length of the backing sheet will thus be the length of the line running through the backing sheet from (a) the point on the edge of the backing sheet at the middle of the wearer's back waist, through the crotch, to (b) the point on the opposite edge of the backing sheet at the middle of the wearer's front waist.

In the usual instance wherein the upper layer of the absorbent core generally defines the shape of the absorbent article, the normal length of the elongated article backing sheet will be approached by the longest longitudinal dimension of the upper layer of the core. In such instances the positioning of the hydrogel-containing lower fluid storage layer can also be defined with respect to its location toward the front portion of the elongated upper fluid acquisition/distribution layer. However, in some applications (e.g. adult incontinence articles) wherein bulk reduction or minimum cost are important, the upper fluid acquisition/distribution layer would not take on the general shape of the diaper or incontinence structure. Rather the upper layer would be generally located to cover only the genital region of the wearer and could in this case have approximately the same top surface area as the lower fluid storage layer. In this instance both the upper fluid acquisition/-distribution layer and the co-extensive lower fluid storage layer would be located toward the front of the article as defined by the backing sheet such that the requisite percentages of lower layer hydrogel would be found in the front two-thirds and front half sections respectively of the article.

The lower fluid storage layer of the absorbent core can be of any desired shape consistent with comfortable fit including, for example, circular, rectangular, trapezoidal or oblong, e.g., hourglass-shaped, dog-bone-shaped or oval. This lower fluid storage layer need not be physically separated from the upper fluid acquisition/distribution layer and can simply form a zone of high hydrogel concentration in a continuous web of fiber material. More preferably, however, the lower fluid storage layer of the absorbent core will comprise a separate web which can be used as an insert placed underneath a larger elongated upper acquisition/distribution layer. If desired, such an insert can be wrapped in a high wet strength envelope web such as tissue paper or a synthetic fine pore, e.g., nonwoven, material, to minimize the potential for hydrogel particles to migrate out of the insert layer. Another objective of such overwrapping is to desirably increase the in-use integrity of the dual layer core. Such a web can, in fact, be glued to the lower fluid storage insert layer. Suitable means for carrying out this gluing operation include the glue spraying procedure described in Minetola and Tucker; U.S. patent application Ser. No. 651,374, filed Sept. 17, 1984, incorporated herein by reference.

In preferred embodiments, the lower fluid storage layer of the absorbent core will be oblong. In especially preferred embodiments, an oblong insert overwrapped with spray-glued tissue will be employed.

One embodiment of an absorbent article according to the present invention comprises a disposable diaper such as that shown in the drawing. This drawing shows an hourglass-shaped diaper structure comprising a liquid impervious elongated sheet **101** and a hydrophobic water pervious topsheet **102**. The absorbent core of the structure comprises two separate layers, i.e., an upper, hourglass-shaped, fluid acquisition/distribution layer **103** and a smaller, lower, oval insert fluid storage layer upper layer **103** comprises a web of air-laid cellulose fibers. The lower oval insert layer **104** comprises a web of cellulose fibers and contains discrete particles **105** of water-insoluble hydrogel distributed throughout this lower oval insert layer. The lower oval insert layer **104** positioned beneath the upper layer **103** toward the front of the diaper. In this manner at least 90% of the hydrogel material **105** in the lower insert layer **104** is found underneath the front two-thirds section of the upper layer **103** and at least 60% of this hydrogel material **105** is found underneath the front half section of the upper layer **103**.

Another embodiment of the present invention relates to disposable, dual-layered absorbent cores per se which could be removably affixed, for example, to semi-disposable, reusable backsheets. Such cores are essentially the same as those described hereinbefore for use in the disposable absorbent articles of this invention. However, the positioning of the hydrogel in the lower fluid storage layer of such cores per se must be defined with respect to the front two-thirds and front half sections of the elongated upper fluid acquisition/distribution layer of the core. Thus the disposable cores per se utilize a lower fluid storage layer which is particularly positioned with respect to the upper fluid acquisition/-distribution layer, or which has nonuniform hydrogel distribution therein, such that at least about 75% of the lower layer hydrogel is found in the front two-thirds section of the elongated core as defined by the length of upper layer and at least about 55% of the lower layer hydrogel is found in the front half section of the core as

defined by the length of the elongated upper layer. Such disposable cores per se are preferably overwrapped or at least covered on top with liquid pervious topsheet material, e.g. tissue or non-woven material as hereinbefore described.

The absorbent articles and absorbent cores of the present invention, with their separate, particularly positioned zones containing fiber material and hydrogel material in particular amounts, are further illustrated by the following examples:

EXAMPLE I

A dual core disposable diaper is prepared utilizing a thermally bonded polypropylene topsheet, an hourglass-shaped primary core positioned below the topsheet, an oval insert positioned underneath the hourglass-shaped core and a fluid-impervious polyethylene backing sheet underneath the hourglass and insert core layers. The hourglass primary core comprises a major amount of cellulose wood pulp fiber and a minor amount of discrete particles of a starch acrylate hydrogel material. The oval insert layer comprises an air-laid mixture of cellulose wood pulp fibers and discrete particles of the same starch acrylate hydrogel material, present in a concentration significantly higher than in the hourglass layer. The oval insert is positioned toward the front of the hourglass such that 90% of the hydrogel material in the insert layer is found within the front two-thirds section of the disposable diaper and such that about 60% of the hydrogel in the insert is in the front half of the disposable diaper.

The two layers of the absorbent core of the diaper of this Example I are more completely described in Table I.

TABLE I

Hourglass:	
Density	0.22 g/cm^3
Basis Weight	0.033 g/cm^2
Area	643 cm^2
% Hydrogel*	2% by weight of hourglass
Insert	
Density	0.22 g/cm^3
Basis Weight	0.05 g/cm^2
Area	221 cm^2
% Hydrogel	20% by weight of insert
Overall Hydrogel Content:	8.1% by weight of total core

*The hydrogel is Sanwet IM-1000, a starch acrylate material marketed by Sanyo Chemical Industries, Inc.

EXAMPLE II

Another dual core disposable diaper is prepared which is similar in construction to the Example I diaper. In this Example II article, the hourglass-shaped upper fluid acquisition/distribution layer of the absorbent core contains no hydrogel material at all so that all of the hydrogel in the diaper is found in the smaller oval insert layer. Again, the insert is positioned under the hourglass upper layer toward the front of the diaper such that 100% of the hydrogel material in the oval insert layer is found in the front two-thirds section of the diaper and such that about 60% of the hydrogel material in the oval insert is found in the front half of the diaper.

In this embodiment, the oval insert layer is overwrapped with spray glued high wet strength tissue to prevent particles of hydrogel from migrating from the oval insert core to other parts of the diaper. The disposable diaper of this example is more completely described in Table II.

TABLE II

Hourglass:	
Dimensions	$15\frac{1}{4} \times 10$ in. (38.7×25.4 cm)
Area	100 in^2 (645 cm^2)
Density	0.18 g/cm^3
Basis Weight	0.19 g/in^2 (0.02945 g/cm^2)
Insert:	
Dimensions	$9 \times 5\frac{1}{4}$ in. (22.9×13.3 cm)
Area	41.3 in^2 (266 cm^2)
Density	0.18 g/cm^3
Basis Weight	0.31 g/in^2 (0.048 g/cm^2)
Hydrogel* Content	4.95 gm (36% by weight of insert)

*The hydrogel is Sanwet IM-1000 marketed by Sanyo Chemical Industries, Inc.

EXAMPLE III

Fluid retention effectiveness of diapers such as described in Example I is determined by means of a leakage study. In such a leakage study, diapers are actually worn by infants. The infants are allowed to play in a nursery school-like setting during the test. The diapers are left on the infants until leakage occurs. In order to speed up the test, aliquots of synthetic urine are added at predetermined levels. The results of the leakage tests are reported in terms of average fluid capacity of the diaper at failure. By assuming that the cellulose fiber portion of the diaper core will hold about 4.0–4.5 grams of fluid per gram of fiber, it is possible to ca an approximate overall effective hydrogel capacity in terms of grams of fluid held per gram of hydrogel under simulated usage conditions.

The diapers tested in the leakage study were diapers of the Example I type having an hourglass-shaped primary absorbent core and an oval insert core positioned beneath the hourglass core and placed toward the front of the diaper. Density, basis weight and surface area of these two cores are as shown in Table 1. The amount of hydrogel in the hourglass and the insert is then varied as set forth in Table III.

TABLE III

Diaper No.	1	2	3	4	5	6
% Hydrogel in Hourglass	15	10	6	2	6	2
% Hydrogel in Insert	15	10	25	30	15	20
Overall Hydrogel Content %	15	10	12.5	11.6	9.1	8.1
Results						
Mean Capacity at Diaper Failure (g)	226	195	244	234	209	231
Overall Effective Hydrogel Capacity (g/g)	21.8	21.6	30.3	29.4	28.6	39.4

The Table III data indicate that by placing most of the hydrogel particles in a forward positioned insert core, effective hydrogel capacity can be increased. Furthermore, it can be seen that diaper capacity for all of these diaper executions is not significantly different even though diapers 3, 4, 5 and 6 with the hydrogel mostly in the insert use a smaller total amount of hydrogel.

EXAMPLE IV

The diaper of Example II having no hydrogel in the primary upper layer is also tested in a leakage study. Performance of the Example II diaper was compared with that of a similar dual core diaper having hydrogel uniformly distributed throughout both an hourglass-shaped primary core and a smaller oval insert placed underneath the hourglass. Again measurements for overall diaper capacity at failure and hydrogel effi-

ciency in terms of fluid held per gram of hydrogel were determined. Also determined was the extent of fluid wicking which occurs in the primary hourglass-shaped upper core layer.

Diapers tested, leakage study and wicking results are shown in Table IV.

TABLE IV

Diaper Type	Hydrogel in Insert Only	Uniform Hydrogel Distribution
Cellulose Fiber	28.6 g	27.5 g
Hydrogel	4.95 g	6.13 g
Tissue	2.2 g	2.3 g
Avg. Overall Urine Load (g)	291	282
Avg. Hydrogel Efficiency (g/g)	29.75	24.2
Avg. Length of Dry Core at Back (cm)	0.76	4.62

The Table IV data demonstrate the improved efficiency of hydrogel fluid absorption performance which can be realized by placing the hydrogel exclusively in a particular type of smaller insert core positioned toward the front of the diaper. The Table IV data also demonstrate that the hydrogel-free hourglass core tends to provide better wicking performance than a hydrogel-containing hourglass. It should be noted, however, that even though urine wicks further to the back of the hourglass-shaped core in diapers of this invention, there is still substantially no rewet of the skin through the topsheet at the back portion of the diaper. This is so because urine load at the rear of the hourglass is relatively small compared to urine load in the insert.

The diapers of Examples I and II are, in fact, especially effective in capturing discharged urine and holding such urine in the hydrogel-containing lower fluid storage layer of the diaper. There is thus substantially no contact of diapered skin with mixtures of urine and feces. Such separation of urine and feces into different regions of the diaper can provide a significant skin condition benefit in terms of prevention or reduction of the incidence of diaper rash.

EXAMPLES V–IX

Several dual core diaper executions similar to that of Example I are prepared and tested in comparision with a control diaper having hydrogel uniformly distributed in a single hour-glass-shaped core. The dual core diapers all have an upper, hourglass-shaped fluid acquisition/distribution layer which is approximately 38.7 cm long×25.4 cm wide (625 cm^2 in area) and a tissue-wrapped, oblong fluid-storage, lower insert layer which is approximately 25.4 cm long×11.4 cm wide (270.9 cm^2 in area). The amounts of cellulose fiber hydrogel in each layer are varied, but in all instances the lower, fluid storage insert layer is positioned toward the front of the diaper such that at least about 90% of the hydrogel material in the insert is found in the front two-thirds section of the diaper and at least about 60% of the hydrogel in the insert is found in the front half of the diaper. The control diaper has a single, tissue-wrapped hour-glass-shaped core which is approximately 38.7 cm long×21.6 cm wide (614.2 cm^2 in area).

All of these diapers are described in greater detail in Table V. Table V also includes an indication of the relative cost of materials used in the dual-layer core diaper cores vis-a-vis to the cost of materials used in the core of the single core diaper.

TABLE V

	Example No.					
	Control	V	VI	VII	VIII	IX
	Core Type					
	Uniform Single Layer	D/L	D/L	D/L	D/L	D/L
Absorbent Materials		(upper/lower)	(upper/lower)	(upper/lower)	(upper/lower)	(upper/lower)
Cellulose Fiber (gm)	37.8	18.8/10.4	23/11.0	23.4/11.3	19.6/12.3	23.5/12.1
Hydrogel* (gm)	6.13	0/4.5	1.2/2.3	/6.3	0/3.1	0/4.8
Percent Hydrogel in Cellulose (%)	14.0	0/30	5/17	0/36	0/20	0/28.4
Tissue (gm)	2.3	0/3.5	0/3.5	0/4.4	0/2.2	0/2.2
Basis Weight in Crotch (g/cm^2)	0.10	0.033/0.059	0.039/0.048	0.36/0.060	0.030/0.054	0.036/0.058
Density in Crotch (g/cm^3)	0.14	0.10/0.14	0.11/0.12	0.11/0.14	0.10/0.12	0.10/0.13
Relative Absorbent Core Cost (%)	100	81	81	104	72	92

*The hydrogel is Sanwet IM-1000 marketed by Sanyo Chemical Industries, Inc.
D/L = Dual Layer

The single layer and dual layer core diapers of Table V are tested in two types of leakage studies. One such study is of the same general type described in Example III hereinbefore. In addition to providing the overall average urine load at failure and the effective average hydrogel load, such a test also provides measurements of several additional diaper performance parameters. For example, by carefully visually inspecting and by dissecting the diaper at the end of the wearing period, it can be determined whether the diaper core held together and did not tear under the stresses of wearing and loading. It is also possible to determine the percent of urine held by each layer of the diaper, e.g., percent of urine held in the fluid storage layer. Finally, it is possible to determine the extent of wicking provided by the acquisition/distribution layer by measuring how far back the acquisition/distribution layer has been wetted.

In a second type of leakage study, diapers are worn by infants in the home under actual usage conditions. Mothers weigh the test diapers at the time of removal and observe and record the extent to which leakage has occurred. In this manner, it is possible to calculate the percent of diapers in the test that fail up to given loading levels.

Results from these two types of leakage studies are provided in Table VI. The Table VI data represent an average of several tests. Not all types of leakage data are available for every diaper type tested.

TABLE VI

Preformance Evaluation	Control	V	VI	VII	VIII	IX
		Example No.				
		Core Type				
	Uniform Single Layer	D/L	D/L	D/L	D/L	D/L
(1) Leakage Study						
Avg. Overall Urine Load (g)	312	337	N/A	399	298	343
Avg. Hydrogel Load (g/g)	21.4	44.0	N/A	36.7	47.4	36.9
% Urine Held in Lower Core (%)	—	81	N/A	73	70	71
Avg. Length of Dry Core at Back (cm)	8.8	0.6	N/A	0.79	0.25	1.8
% Reduction in Diaper Core Tearing Versus Base (Accelerated Usage Conditions) (%)	Base	N/A	N/A	100	93	46
(2) Percent Leakage in Home Study (Overnight Use)						
% of Diapers Failed at Loadings up to 150 g. of Urine (%)	4.6	0.3	1.8	N/A	N/A	1.3
% of Diapers Failed at Loadings up to 300 g. of Urine (%)	12.0	6.8	8.1	N/A	N/A	4.6

N/A = Not Available
D/L = Dual Layer

The Table VI data illustrate that there are a number of important advantages provided by the diaper constructions utilizing the dual core configuration of this invention. In the first place, it can be seen that the hydrogel is much more efficiently utilized as best indicated by the improved hydrogel load values in comparison with the control. Furthermore, the storage layer contains most of the fluid (e.g., 70–80%) even though it provides less than half of the absorbent weight. This is desirable since fluid stored in this layer is more resistant to release upon pressure. Thus the diapers of the present invention minimize the release of fluid back through the topsheet, thereby keeping the infant's skin drier. It should also be noted that by having most of the fluid held in the fluid storage layer positioned toward the front of the diaper, there is a significantly reduced tendency for urine to mix with feces at the back of the the diaper in contact with the wearer's skin.

The Table VI data also demonstrate that wicking in the dual layer core products is much more efficient as shown by the much smaller dry area at the back of the acquisition/distribution layer of the core. Furthermore, it can be seen that the dual layer core structure has improved resistance to tearing as shown by the percent reduction in diaper tearing versus the base non-layered core product.

Finally the Table VI data show that higher diaper capacity can be obtained at similar relative cost of core material or, alternatively, that approximately equal diaper capacity can be realized for 20–30% less cost in comparison with single uniform core structures due to the more efficient use and placement of the hydrogel material. Even when the dual layer core products are designed to have equal capacity to homogenous core products in a leakage study context, the dual layer design will have fewer leaks in home use because their performance is more reliable as well as more efficient. Such better reliability is best illustrated by the lower percent leakages in the home testing under overnight stress use.

What is claimed is:

1. A disposable absorbent article comprising:

(A) a liquid impervious, elongated backing sheet;

(B) a relatively hydrophobic, liquid pervious topsheet; and

(C) a layered absorbent core positioned between said backing sheet and said topsheet, said core comprising:

(i) an upper fluid acquisition/distribution layer having a density of from about 0.05 to 0.25 g/cm^3 and consisting essentially of hydrophilic fiber material and from 0% to about 8% by weight of said upper layer of particles of substantially water-in-soluble hydrogel material; and

(ii) a lower fluid storage layer having a density of from about 0.06 to 0.3 g/cm^3 and consisting essentially of a substantially uniform combination of hydrophilic fiber material and from about 9% to 60% by weight of said lower layer of particles of substantially water-insoluble hydrogel material;

said lower fluid storage layer having a top surface area which is from about 0.25 to 1.0 times that of said upper fluid acquisition/distribution layer and said lower fluid storage layer further being positioned relative to said backing sheet and said upper layer in a manner such that at least about 75% of the hydrogel material in said lower layer is found within the front two-thirds section of said absorbent article and such that at least about 55% of the hydrogel material in said lower layer is found within the front half section of said absorbent article.

2. An article according to claim 1 wherein

(A) the upper fluid acquisition/distribution layer is elongated and has a density which ranges from about 0.07 to 0.14 g/cm^3;

(B) the lower fluid storage layer comprises an intimate admixture of hydrophilic fiber material and hydrogel particles and has a density which ranges from about 0.09 to 0.18 g/cm^3;

(C) the lower fluid storage layer contains from about 15% to 40% by weight of said lower layer of hydrogel material substantially uniformly distributed throughout a hydrophilic fiber matrix;

(D) the lower fluid storage layer has a top surface area which is from about 0.25 to 0.75 times that of said upper layer; and

(E) at least about 90% of the hydrogel material in said lower fluid storage layer is found in the front two-

thirds section of the absorbent article and at least about 60% of the hydrogel material in the lower fluid storage layer is found in the front half section of the absorbent article.

3. An article according to claim 1 wherein the fluid storage layer comprises a laminate of at least two layers of dispersed hydrogel particles separated by and over-wrapped with sheets of hydrophilic fiber material.

4. An article according to claim 1, 2 or 3 wherein the hydrophilic fiber material comprises cellulose fibers and wherein the substantially water-insoluble hydrogel material is selected from hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates, isobutylene maleic anhydride co-polymers or mixtures of such hydrogel materials.

5. An article according to claim 4 wherein the upper fluid acquisition/distribution layer is substantially free of hydrogel material.

6. An article according to claim 4 wherein the upper fluid acquisition/distribution layer contains hydrogel particles in an amount up to about 6% by weight of said upper layer.

7. An article according to claim 4 wherein

(A) the upper fluid acquisition/distribution layer has a basis weight of from about 0.015 to 0.1 gm/cm^2 and

(B) the lower fluid storage layer has a basis weight of from about 0.02 to 0.12 gm/cm^2.

8. A disposable diaper article comprising

(A) a liquid-impervious, elongated backing sheet;

(B) a relatively hydrophobic, liquid pervious top-sheet;

(C) a layered absorbent core positioned between said backing sheet and said topsheet, said absorbent core comprising;

(i) an elongated upper fluid acquisition/distribution layer having a density of from about 0.07 to 0.14 g/cm^3, consisting essentially of hydrophilic fiber material, and being substantially free of hydrogel material; and

(ii) a lower fluid storage layer having a density of from about 0.09 to 0.18 g/cm^3 and consisting essentially of an intimate admixture of hydrophilic fiber material and from about 9% to 60% by weight of said lower layer of particles of substantially water-insoluble hydrogel material;

said lower fluid storage layer having a top surface area which is from about 0.25 to 0.75 times that of said upper fluid acquisition/distribution layer and said lower fluid storage layer further being positioned relative to said backing sheet and said upper fluid acquisition/distribution layer in a manner such that at least about 90% of the hydrogel material in said lower layer is found within the front two-thirds section of said diaper article and such that at least about 60% of the hydrogel material in said lower layer is found within the front half section of said diaper article.

9. A diaper article according to claim 8 wherein the hydrophilic fiber material comprises cellulose fibers and wherein the substantially water-insoluble hydrogel material is selected from hydrolyzed acrylonitrile-grafted starch, acrylic acid grafted starch, polyacrylates, isobutylene maleic anhydride co-polymers or mixtures of such hydrogel materials.

10. A diaper article according to claim 8 or 9 wherein

(A) the upper fluid acquisition/distribution layer is generally hourglass-shaped and has a basis weight of from about 0.015 to 0.1 gm/cm^2; and

(B) the lower fluid storage layer is generally oblong and has a basis weight of from about 0.02 to 0.12 gm/cm^2.

11. A diaper article according to claim 10 wherein said generally oblong lower fluid storage layer/comprises an air laid mixture of cellulose fibers and particles of substantially water-insoluble hydrogel material.

12. A diaper article according to claim 10 wherein the particles of hydrogel in said lower fluid storage layer range in size from about 50 microns to 1 mm and wherein said particles comprise from about 15% to 40% by weight of said lower layer.

13. A disposable diaper article comprising

(A) a liquid-impervious, elongated backing sheet;

(B) a relatively hydrophobic, liquid pervious top-sheet; and

(C) a layered absorbent core positioned between said backing sheet and said topsheet, said absorbent core comprising:

(i) an elongated upper fluid acquisition/distribution layer having a density of from about 0.07 to 0.14 g/cm^3, and consisting essentially of hydrophilic fiber material and up to about 6% by weight of said upper layer of particles of substantially water-insoluble hydrogel material; and

(ii) a lower fluid storage layer having a density of from about 0.09 to 0.18 g/cm^3 and consisting essentially of an intimate admixture of hydrophilic fiber material and from about 15% to 40% by weight of said lower layer of particles of substantially water-insoluble hydrogel material;

lower fluid storage layer having a top surface area which is from about 0.25 to 0.75 times that of said upper fluid acquisition/distribution layer and said lower fluid storage layer further being positioned relative to said backing sheet and said upper fluid acquisition/distribution layer in a manner such that at least about 90% of the hydrogel material in said lower layer is found within the front two-thirds section of said diaper article and such that at least about 60% of the hydrogel material in said lower layer is found within the front half section of said diaper article.

14. A diaper article according to claim 13 wherein the hydrophilic fiber material comprises cellulose fibers and wherein the substantially water-insoluble hydrogel material is selected from hydrolyzed acrylonitrile-grafted starch, acrylic acid grafted starch, polyacrylates, isobutylene maleic anhydride co-polymers or mixtures of such hydrogel materials.

15. A diaper article according to claim 13 or 14 wherein

(A) the upper fluid acquisition/distribution layer is generally hourglass-shaped and has a basis weight of from about 0.015 to 0.1 gm/cm^2; and

(B) the lower fluid storage layer is generally oblong and has a basis weight of from about 0.02 to 0.12 gm/cm^2.

16. A diaper article according to claim 15 wherein said generally oblong lower fluid storage layer comprises an air laid mixture of cellulose fibers and particles of substantially water-insoluble hydrogel material.

17. A diaper article according to claim 15 wherein the particles of hydrogel in said upper and lower layers range in size from about 50 microns to 1 mm.

18. A diaper article according to claim **1**, **2**, **8** or **13** wherein said lower fluid storage layer is a separate insert layer which is over-wrapped with high wet strength envelope web.

19. A diaper article according to claim **18** wherein the envelope web is tissue and is glue-sprayed to the lower fluid storage insert layer.

20. A disposable diaper article comprising

(A) a liquid-impervious, elongated backing sheet;

(B) a relatively hydrophobic, liquid pervious topsheet;

(C) a layered absorbent core positioned between said backing sheet and said topsheet, said absorbent core comprising;

(i) an elongated upper fluid acquisition/distribution layer having a density of from about 0.07 to 0.14 g/cm^2 and consisting essentially of hydrophilic fiber material and from 0% to about 6% by weight of said upper layer of particles of substantially water-insoluble hydrogel material; and

(ii) a lower fluid storage layer having a density of from about 0.06 to 0.3 g/cm^3 and consisting essentially of a laminate of at least two layers of dispersed particles of substantially water-in-soluble hydrogel material separated by and over-wrapped with sheets of tissue, said hydrogel particles comprising from about 9% to 60% by weight of said lower layer;

said lower fluid storage layer having a top surface area which is from about 0.25 to 0.75 times that of said upper fluid acquisition/distribution layer and said lower fluid storage layer further being positioned relative to said backing sheet and said upper fluid acquisition/distribution layer in a manner such that at least about 90% of the hydrogel material in said lower layer is found within the front two-thirds section of said diaper article and such that at least about 60% of the hydrogel material in said lower layer is found within the front half section of said diaper article.

21. A disposable, dual-layer absorbent core suitable for use in an absorbent article, said absorbent core comprising

(A) an elongated upper fluid acquisition/distribution layer having a density of from about 0.05 to 0.25 g/cm^3 and consisting essentially of hydrophilic fiber material and from 0% to about 8% by weight of said upper layer of particles of substantially water-insoluble hydrogel material; and

(B) a lower fluid storage layer having a density of from about 0.06 to 0.3 g/cm^3 and consisting essentially of a substantially uniform combination of hydrophilic fiber material and from about 9% to 60% by weight of said lower layer of particles of substantially water-insoluble hydrogel material;

said lower fluid storage layer having a top surface area which is from about 0.25 to 1.0 times that of said upper fluid acquisition/distribution layer and said lower fluid storage layer further being positioned relative to said upper layer in a manner such that at least about 75% of the hydrogel material in said lower layer is found within the front two-thirds section of said absorbent core and such that at least about 55% of the hydrogel material in said lower layer is found within the front half of said absorbent core.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,673,402

DATED : June 16, 1987

INVENTOR(S) : Paul T. Weisman, Dawn I. Houghton, Dale A. Gellert

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 17, "c le" should be --capable--

Column 2, line 15, "4,333,426" should be --4,333,462--

Column 4, line 67, "December 10, 1963" should be --Issued December 10, 1963--

Column 10, line 38, "upper layer 103" should be --104. The upper layer 103--

Column 10, line 39, "layer 104 comprises" should be --layer 104 also comprises--

Column 10, line 43, "positioned" should be --is positioned--

Column 12, line 27, "ca" should be --calculate--

Column 13, line 65, "Example I" should be --Example II--

Column 14, line 2, "625" should be --625.6--

Column 16, line 32, "water-in-soluble" should be --water-insoluble--

Column 18, line 8, "layer/comprises" should be --layer comprises--

Column 19, line 17, "cm^2" should be --cm^3--

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 4,673,402

DATED : June 16, 1987

INVENTOR(S) : Paul T. Weisman et al

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 19, line 24, "water-in-soluble" should be --water-insoluble--.

Signed and Sealed this

Nineteenth Day of July, 1988

Attest:

DONALD J. QUIGG

Attesting Officer *Commissioner of Patents and Trademarks*

United States Patent [19]

Alemany et al.

[11] **Patent Number: 4,834,735**

[45] **Date of Patent: May 30, 1989**

[54] **HIGH DENSITY ABSORBENT MEMBERS HAVING LOWER DENSITY AND LOWER BASIS WEIGHT ACQUISITION ZONES**

[75] Inventors: **Miguel Alemany; Charles J. Berg,** both of Cincinnati, Ohio

[73] Assignee: **The Proctor & Gamble Company,** Cincinnati, Ohio

[21] Appl. No.: **887,584**

[22] Filed: **Jul. 18, 1986**

[51] **Int. Cl.**^{4} **A61F 13/16**

[52] **U.S. Cl.** **604/368;** 428/213; 428/218; 428/283; 428/284; 428/913

[58] **Field of Search** 428/283, 284, 213, 218, 428/913; 604/368

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Primary Examiner—James J. Bell
Attorney, Agent, or Firm—Steven W. Miller; John M. Pollaro; Fredrick H. Braun

[57] **ABSTRACT**

An absorbent article wherein the deposition region of its absorbent member comprises a storage zone and an acquistion zone having a lower average density and a lower average basis weight per unit area than the storage zone. The acquisition zone is positioned toward the front of either the absorbent member or the absorbent article so that the acquistion zone may most effectively and efficiently rapidly acquire discharged liquids. The absorbent member also comprises a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material to enhance the absorbent capacity of the absorbent member.

78 Claims, 3 Drawing Sheets

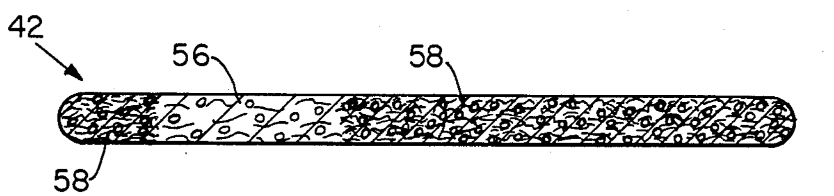


Fig. 1

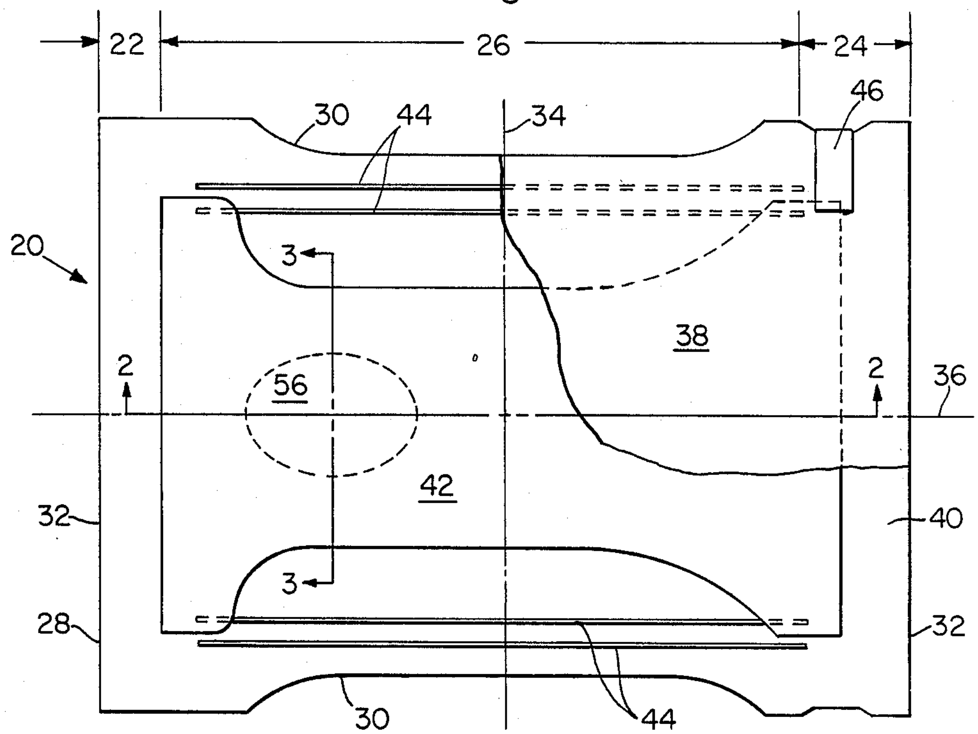


Fig. 2

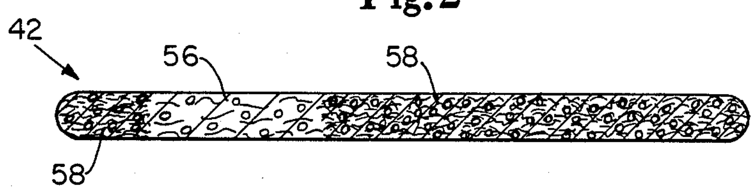
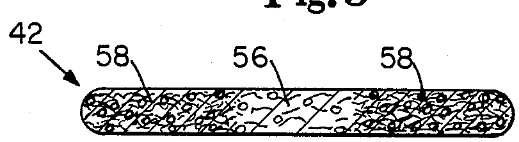


Fig. 3



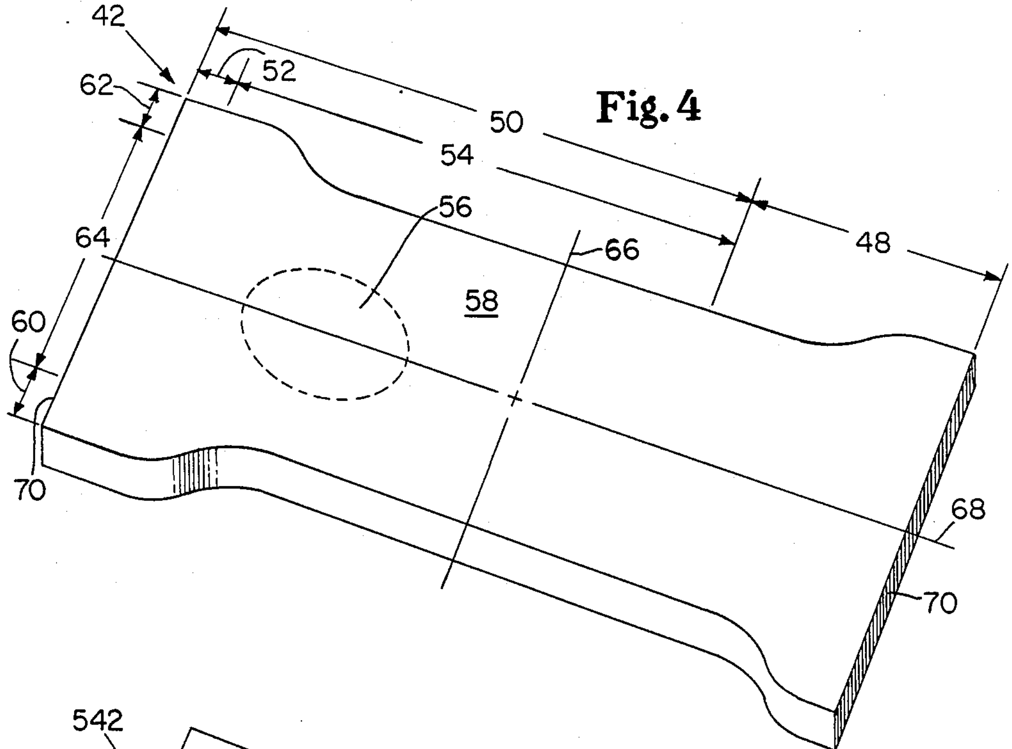

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Fig. 4

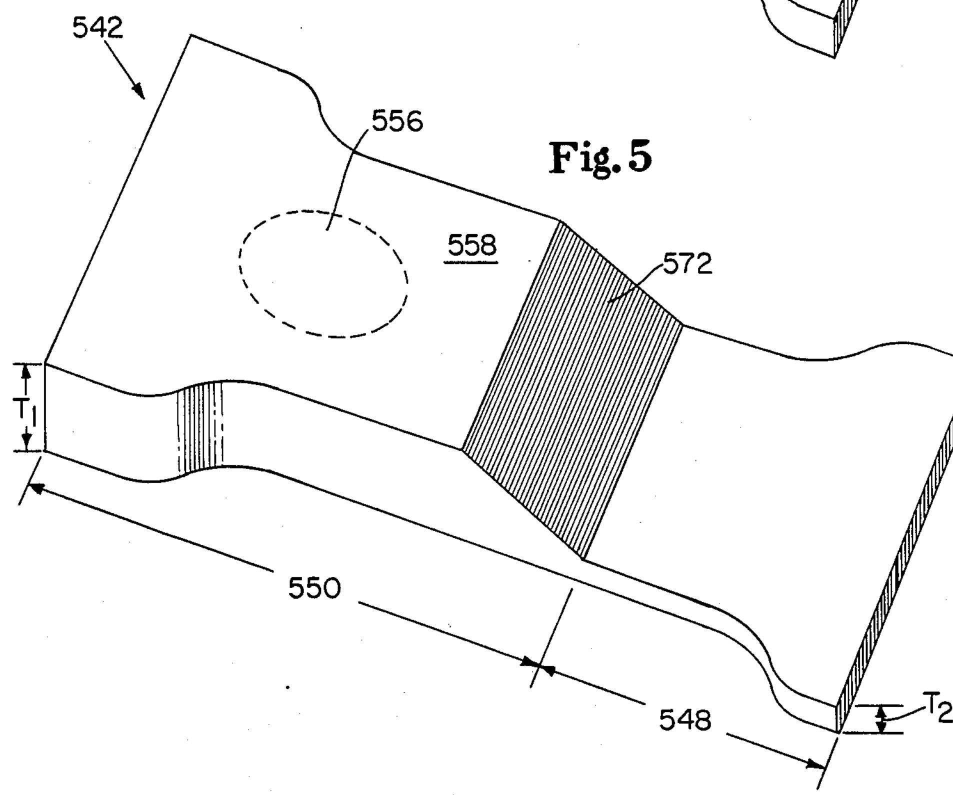
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Fig. 5

Fig. 6

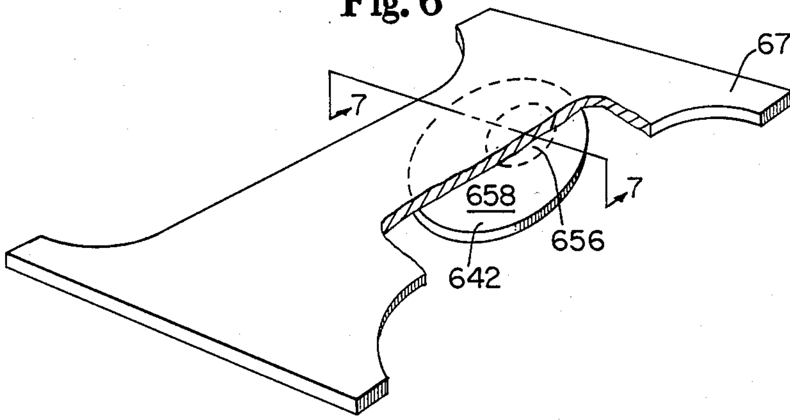


Fig. 7

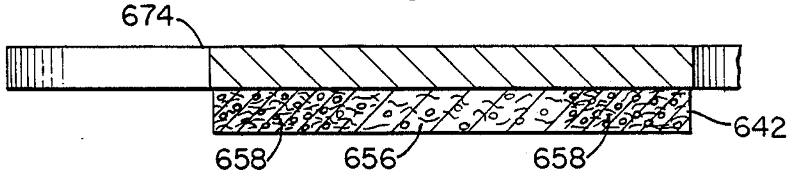
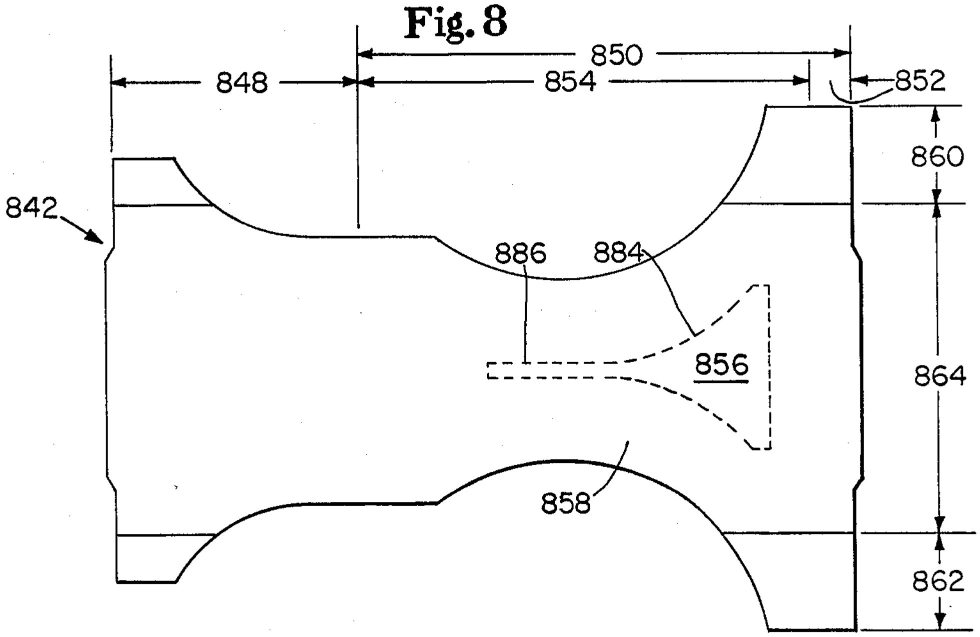


Fig. 8



HIGH DENSITY ABSORBENT MEMBERS HAVING LOWER DENSITY AND LOWER BASIS WEIGHT ACQUISITION ZONES

FIELD OF THE INVENTION

This invention relates to absorbent members having a mixture of hydrophillic fibrous material and discrete particles of an absorbent gelling material. More particularly, the invention relates to a relatively high density absorbent member having a relatively lower average density and lower average basis weight acquistion zone positioned in the area of typical liquid deposition to more quickly acquire and distribute liquids within the absorbent member.

BACKGROUND OF THE INVENTION

Absorbent articles such as disposable diapers, adult incontinent pads, sanitary napkins and the like are generally provided with absorbent members to receive and retain body liquids. In order for such absorbent articles to function efficiently, the absorbent members must quickly acquire body liquids into the structure from the point of application and subsequently distribute the body liquids within and throughout the absorbent member to provide maximum leakage containment. In addition, the absorbent members should be capable of retaining liquids when placed under loads. Prior art attempts to improve the effectiveness of such absorbent members have included distributing particles of absorbent gelling material throughout or in portions of the absorbent member. For example, Procter & Gamble; European Patent Application EP-A-122,042; published Oct. 17, 1984 discloses absorbent members wherein particles of absorbent gelling material (hydrogel) are dispersed in an air-laid web of hydrophilic fibrous material and compressed to a particular density. In addition, United States patent application Ser. No. 734,426; filed May 15, 1985, by Paul T. Weisman, Dawn I. Houghton and Dale A. Gellert discloses a dual-layer absorbent core wherein an absorbent acquisition layer overlays a lower fluid storage layer that consists essentially of a uniform combination of hydrophilic fibrous material and discrete particles of absorbent gelling material.

Absorbent gelling materials are polymeric materials which are capable of absorbing large quantities of liquids relative to their weight such as water and body wastes, and which are further capable of retaining such absorbed liquids under moderate pressures. These absorption characteristics of absorbent gelling materials make them especially useful for incorporation into absorbent articles such as disposable diapers, adult incontinent pads, sanitary napkins and the like. However, in spite of the extremely high absorption capacities of such absorbent gelling materials, their performance when used in disposable absorbent articles has still not been optimized.

The effectiveness of absorbent gelling materials in disposable absorbent articles is quite dependent upon the form, position, and/or manner in which the particles of absorbent gelling material are incorporated into the absorbent member. In some cases, for example, the effectiveness of absorbent members containing particles of absorbent gelling material can be adversely affected by a phenomenon called gel blocking. The term gel blocking describes a situation that occurs when a particle of absorbent gelling material is wetted, the surface of the particles swelling so as to inhibit liquid transmission into the interior of the absorbent member. Wetting of the interior of the absorbent member, therefore, takes place via a very slow diffusion process. In practical terms, this means that acquisition of liquids by the absorbent member is much slower than the discharge of the liquid to be absorbed, and leakage from the absorbent article may take place well before the particles of absorbent gelling material in the absorbent member are fully saturated or before the liquid can diffuse or wick past the "blocking" particles into the rest of the absorbent member. The slow acquisition rate also fails to take advantage of the rapid wicking of liquids to other parts of the absorbent member provided by a densified absorbent member containing particles of absorbent gelling material.

Thus, it would be advantageous to provide an absorbent member that more quickly acquires and distributes liquids within itself while minimizing gel blocking during the liquid acquisition phase. It is therefore a primary objective of the present invention to provide absorbent members which are especially effective and efficient in their use of absorbent gelling materials.

SUMMARY OF THE INVENTION

The present invention provides an absorbent article such as disposable diapers, incontinent pads, sanitary napkins or the like that has an absorbent member that is suitable for acquiring and containing liquids in an especially effective and efficient manner. Such an absorbent article comprises a liquid pervious topsheet, a liquid impervious backsheet, and an absorbent member positioned between the topsheet and the backsheet.

The absorbent member has a deposition region which comprises a storage zone of a relatively high density and high basis weight to absorb and retain liquids acquired by the absorbent member and an acquisition zone of a relatively lower average density and lower average basis weight than the storage zone to quickly acquire and temporarily hold discharged liquids. The absorbent member also comprises a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material.

In accordance with one aspect of the present invention, the acquisition zone is positioned toward the front of the absorbent member so that the acquisition zone may be positioned in the area of typical liquid deposition. The acquisition zone is also sized so that the top surface area of the acquisition zone comprises less than about 50% of the top surface area of the front section of the absorbent member.

In accordance with another aspect of the present invention, the ratio of the average density of the storage zone to the average density of the acquisition zone is preferably about equal to or greater than 1.25:1, and most preferably about equal to or greater than 2:1. The acquisition zone preferably has a density of from about 0.05 to about 0.15 g/cm^3; the acquisition zone also preferably having a uniform density and uniform basis weight throughout.

In a preferred embodiment of the present invention, a relatively high gel strength absorbent gelling material is mixed with hydrophilic fibrous material to not only minimize gel blocking but also to help maintain an open capillary structure within the absorbent member to enhance planar transport of liquids away from the area of typical liquid deposition to the rest of the absorbent member. The mixture of hydrophilic fibrous material

and discrete particles of absorbent gelling material preferably have a fiber-to-particulate weight ratio of from about 40:60 to about 98:2, more preferably about 50:50 to about 91:9.

The present invention also relates to dual-layer absorbent cores of the type having an absorbent acquisition core which consists essentially of hydrophilic fibrous material and an absorbent member which consists of a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material. The absorbent member has a top surface area which is from about 0.25 to about 1.0 times the top surface area of the absorbent acquisition core. The absorbent member is further positioned relative to the backsheet of the absorbent article in which its positioned such that at least about 75% of the absorbent gelling material is found within the front two-thirds portion of the absorbent article. The acquisition zone of the absorbent member is also positioned relative to the backsheet such that it is completely positioned within the front two-thirds portion of the absorbent article.

DETAILED DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims which particularly point out and distinctly claim the subject matter regarded as forming the present invention, it is believed the invention will be better understood from the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a plan view of a disposable diaper embodiment of the present invention wherein most of the topsheet has been cut-away to more clearly show the underlying absorbent member of the diaper;

FIG. **2** is a longitudinal sectional view of only the absorbent member of the disposable diaper taken along sectional line 2—2 of FIG. **1**;

FIG. **3** is a transverse sectional view of only the absorbent member of the disposable diaper taken along sectional line 3—3 of FIG. **1**;

FIG. **4** is a perspective view of the absorbent member of the disposable diaper shown in FIG. **1**;

FIG. **5** is a perspective view of an alternative embodiment of the absorbent member of the present invention;

FIG. **6** is a perspective view of a dual-layer absorbent core having a further alternative embodiment of the absorbent member of the present invention;

FIG. **7** is a sectional view of the dual-layer absorbent core of FIG. **6** taken along sectional line 7—7 of FIG. **6**; and

FIG. **8** is a plan view of a still further alternative embodiment of the absorbent member of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The absorbent members of the present invention will be described herein in relationship to their use in disposable absorbent articles; however, it should be understood that the potential application of the absorbent members of the present invention should not be limited to disposable absorbent articles. As used herein, the term "disposable absorbent article" refers to articles which absorb and contain body exudates and more specifically refers to articles which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body, and which are intended to be discarded after a single use (i.e., they are not intended to be laundered or otherwise restored or reused). A preferred embodiment of a disposable absorbent article, diaper **20**, is shown in FIG. **1**. As used herein, the term "diaper" refers to a garment generally worn by infants and incontinent persons that is worn about the lower torso of the wearer. It should be understood, however, that the present invention is also applicable to other disposable absorbent articles such as incontinent briefs, sanitary napkins, and the like.

FIG. **1** is a plan view of the diaper **20** of the present invention in its flat-out, uncontracted state (i.e., with all elastic induced contraction removed) with portions of the structure being cut-away to more clearly show the construction of the diaper **20** and with the portion of the diaper **20** which contacts the wearer facing the viewer. The diaper **20** is shown in FIG. **1** to have a front waistband region **22**, a back waistband region **24**, a crotch region **26** and a periphery **28** which is defined by the outer edges of the diaper in which the longitudinal edges are designated **30** and the end edges are designated **32**. The diaper additionally has a transverse centerline which is designated **34** and a longitudinal centerline which is designated **36**.

The diaper **20** comprises a liquid pervious topsheet **38**; a liquid impervious backsheet **40**; an absorbent member **42**; and elastic members **44**. While the topsheet **38**, the backsheet **40**, the absorbent member **42**, and the elastic members **44** may be assembled in a variety of well known configurations, a preferred diaper configuration is described generally in U.S. Pat. No. 3,860,003 entitled "Contractable Side Portions for Disposable Diaper", which issued to K. B. Buell on Jan. 14, 1975, and which patent is incorporated herein by reference.

FIG. **1** shows a preferred embodiment of the diaper **20** in which the topsheet **38** and the backsheet **40** are co-extensive and have length and width dimensions generally larger than those of the absorbent member **42**. The topsheet **38** is associated with and superimposed on the backsheet **40** thereby forming the periphery **28** of the diaper **20**. The periphery **28** defines the outer perimeter or the edges of the diaper **20**. The periphery **28** comprises the end edges **32** and longitudinal edges **30**.

The diaper **20** has front and back waisband regions **22** and **24** respectively, extending from the end edges **32** of the diaper periphery **28** toward the transverse centerline **34** of the diaper a distance from about 2% to about 10%, preferably about 5%, of the length of the diaper **20**. The waistband regions comprise those upper portions of the diaper **20**, which when worn, encircle the waist of the wearer. The crotch region **26** is that portion of the diaper **20** between the waistband regions **22** and **24**, and comprises that portion of the diaper **20** which, when worn, is positioned between the legs of the wearer and covers the lower torso of the wearer. Thus, the crotch region **26** defines the area of typical liquid deposition for a diaper **20** or other disposable absorbent article.

The topsheet **38** is compliant, soft feeling, and non-irritating to the wearer's skin. Further, the topsheet **38** is liquid pervious permitting liquids to readily penetrate through its thickness. A suitable topsheet **38** may be manufactured from a wide range of materials, such as porous foams, reticulated foams, apertured plastic films, natural fibers (e.g., wood or cotton fibers), synthetic fibers (e.g., polyester or polypropylene fibers) or from a combination of natural and synthetic fibers. Preferably, the topsheet **38** is made of a hydrophobic material to

isolate the wearer's skin from liquids in the absorbent member **42**.

A particularly preferred topsheet **38** comprises staple length polypropylene fibers having a denier of about 1.5, such as Hercules type 151 polypropylene marketed by Hercules, Inc. of Wilmington, Del. As used herein, the term "staple length fibers" refers to those fibers having a length of at least about 15.9 mm (0.62 inches).

There are a number of manufacturing techniques which may be used to manufacture the topsheet **38**. For example, the topsheet **38** may be woven, non-woven, spunbonded, carded, or the like. A preferred topsheet is carded, and thermally bonded by means well known to those skilled in the fabrics art. Preferably, the topsheet **38** has a weight from about 18 to about 25 grams per square meter, a minimum dry tensile strength of at least about 400 grams per centimeter in the machine direction and a wet tensile strength of at least about 55 grams per centimeter in the cross machine direction.

The backsheet **40** is impervious to liquids and is preferably manufactured from a thin plastic film, although other flexible liquid impervious materials may also be used. The backsheet **40** prevents the exudates absorbed and contained in the absorbent member **42** from wetting articles which contact the diaper **20** such as bed sheets and undergarments. Preferably, the backsheet **40** is polyethylene film having a thickness of from about 0.012 mm (0.5 mil) to about 0.051 centimeters (2.0 mils), although other flexible, liquid impervious materials may be used. As used herein, the term "flexible" refers to materials which are compliant and which will readily conform to the general shape and contours of the wearer's body.

A suitable polyethylene film is manufactured by Monsanto Chemical Corporation and marketed in the trade as Film No. 8020. The backsheet **40** is preferably embossed and/or matte finished to provide a more clothlike appearance. Further, the backsheet **40** may permit vapors to escape from the absorbent member **42** while still preventing exudates from passing through the backsheet **40**.

The size of the backsheet **40** is dictated by the size of the absorbent member **42** and the exact diaper design selected. In a preferred embodiment, the backsheet **40** has a modified hourglass-shape extending beyond the absorbent member **42** a minimum distance of at least about 1.3 centimeters to about 2.5 centimeters (about 0.5 to about 1.0 inch) around the entire diaper periphery **28**.

The topsheet **38** and the backsheet **40** are associated together in any suitable manner. As used herein, the term "associated" encompasses configurations whereby the topsheet **38** is directly joined to the backsheet **40** by affixing the topsheet **38** directly to the backsheet **40**, and configurations whereby the topsheet **38** is indirectly joined to the backsheet **40** by affixing the topsheet **38** to intermediate members which in turn are affixed to the backsheet **40**. In a preferred embodiment, the topsheet **38** and the backsheet **40** are affixed directly to each other in the diaper periphery **28** by attachment means (not shown) such as an adhesive or any other attachment means as known in the art. For example, a uniform continuous layer of adhesive, a patterned layer of adhesive, or an array of separate lines or spots of adhesive may be used to affix the topsheet **38** to the backsheet **40**.

Tape tab fasteners **46** are typically applied to the back waistband region **24** of the diaper **20** to provide a fastening means for holding the diaper on the wearer. Only one of the tape tab fasteners is shown in FIG. **1**. The tape tab fasteners **46** can be any of those well known in the art, such as the fastening tape disclosed in U.S. Pat. No. 3,848,594 issued to K. B. Buell on Nov. 19, 1974, which patent is incorporated herein by reference. These tape tab fasteners **46** or other diaper fastening means, such as pins, are typically applied near the corners of the diaper **20**.

The elastic members **44** are disposed adjacent the periphery **28** of the diaper **20**, preferably along each longitudinal edge **30** so that the elastic members **44** tend to draw and hold the diaper **20** against the legs of the wearer. Alternatively, the elastic members **44** may be disposed adjacent either or both of the end edges **32** of the diaper **20** to provide a waistband as well as or rather than leg cuffs. For example, a suitable waistband is disclosed in U.S. Pat. No. 4,515,595 issued to David J. Kievit and Thomas F. Osterhage on May 7, 1985, which patent is herein incorporated by reference. In addition, a method and apparatus suitable for manufacturing a disposable diaper having elastically contractible elastic members is described in U.S. Pat. No. 4,081,301 entitled "Method and Apparatus for Continuously Attaching Discrete, Stretched Elastic Strands to Predetermined Isolated Portions of Disposable Absorbent Products" which issued to K. B. Buell on Mar. 28, 1978 and which patent is incorporated herein by reference.

The elastic members **44** are secured to the diaper **20** in an elastically contractible condition so that in a normally unrestrained configuration, the elastic members **44** effectively contract or gather the diaper **20**. The elastic members **44** can be secured in an elastically contractible condition in at least two ways. For example, the elastic members **44** may be stretched and secured while the diaper **20** is in an uncontracted condition. Alternatively, the diaper **20** may be contracted, for example, by pleating, and the elastic members **44** secured and connected to the diaper **20** while the elastic members **44** are in their unrelaxed or unstretched condition.

In the embodiment illustrated in FIG. **1**, the elastic members **44** extend essentially the entire length of the diaper **20** in the crotch region **26**. Alternatively the elastic members **44** may extend the entire length of the diaper **20**, or any other length suitable to provide an elastically contractable line. The length of the elastic members **44** is dictated by the diapers' design.

The elastic members **44** may take a multitude of configurations. For example, the width of the elastic members **44** may be varied from about 0.25 millimeters (0.01 inches) to about 25 millimeters (1.0 inch) or more; the elastic members **44** may comprise a single strand of elastic material or may comprise several parallel or non-parallel strands of elastic material; or the elastic members **44** may be rectangular or curvilinear. Still further, the elastic members **44** may be affixed to the diaper in any of several ways which are known in the art. For example, the elastic members **44** may be ultrasonically bonded, heat and pressure sealed into the diaper **20** using a variety of bonding patterns or the elastic members **44** may simply be glued to the diaper **20**.

The absorbent member **42** is positioned between the topsheet **38** and the backsheet **40** to form the diaper **20**. The absorbent member **42** is generally compressible, conformable, non-irritating to the wearer's skin, and capable of absorbing and retaining liquids and certain body exudates. It should be understood that for purposes of this invention that an absorbent member is not necessarily limited to a single layer or sheet of material.

Thus, the absorbent member **42** may actually comprise laminates or combinations of several sheets or webs of the requisite types of materials as hereinafter described. Thus as used herein, the term "member" includes the term "members" or "layers" or "layered."

FIG. **4** is a perspective view of a preferred embodiment of the absorbent member **42** of the present invention. The absorbent member **42** is shown in FIG. **4** to comprise a back section **48** and a front section **50**. The front section **50** is shown to have an end region **52** and a deposition region **54**. The deposition region **54** comprises an acquisition zone **56** (shown by the dotted lines) and a storage zone **58**. Further, the front section **50** is transversely divided into three regions comprising two transversely spaced ear regions **60** and **62** respectively, and a central region **64**. The absorbent member **42** additionally has a transverse centerline which is designated **66** and a longitudinal centerline which is designated **68**.

The absorbent member **42** has a back section **48** and a front section **50** that is contiguous with the back section **48**. The back section **48** and the front section **50** of the absorbent member **42** extend respectively from the end edges **70** of the absorbent member **42** toward the transverse centerline **66**, the front portion **50** extending a distance from about one half to about three-fourths, preferably about two-thirds, of the length of the absorbent member **42**. The front section **50** is preferably greater than one half of the total length of the absorbent member **42** so that it will encompass all of the area of typical liquid deposition of an absorbent member **42** when it is placed in a diaper or other absorbent article.

The front portion **50** has an end region **52** and a deposition region **54**. The end region **52** comprises that portion of the front section **50** extending from the respective end edge **70** of the absorbent member **42** toward the transverse centerline **66** a distance from about 2% to about 10%, preferably about 5%, of the length of the absorbent member **42**. The deposition region **54** comprises that portion of the front portion **50** that is contiguous with and positioned between the end region **52** and the back section **48** and encompasses the area of typical liquid deposition of the absorbent member **42**.

The front portion **50** further has two transversely spaced ear regions **60** and **62** respectively, and a central region **64** disposed intermediate said ear regions **60** and **62**. The ear regions **60** and **62** comprise those portions which generally extend from the longitudinal edges **30** of the periphery **28** toward the longitudinal centerline a distance from about one-tenth to about one-third of the width of the absorbent member **42**. Thus, the ear regions **60** and **62** are those portions that engage the side marginal portions of the wearer's waist and torso, whereas the central region **64** engages the medial portion of the wearer's waist and torso. The central region thus defines the transverse area of typical liquid deposition.

The absorbent member **42** may be manufactured in a wide variety of sizes and shapes (e.g., rectangular, hourglass, asymmetrical, etc.) and from a wide variety of materials. The total absorbent capacity of the absorbent member **42** should, however, be compatible with the design liquid loading for the intended use of the absorbent article or diaper. Further, the size and absorbent capacity of the absorbent member **42** may be varied to accommodate wearers ranging from infants through adults. The absorbent member **42** preferably comprises a mixture of hydrophilic fibrous material and particular amounts of discrete particles of absorbent gelling material.

Various types of hydrophilic fibrous material can be used in the absorbent member **42**. Any type of hydrophilic fibrous material which is suitable for use in conventional absorbent products are suitable for use in the absorbent member **42** of the present invention. Specific examples of such hydrophilic fibrous material include cellulose fibers, rayon, and polyester fibers. Other examples of suitable hydrophilic fibrous materials include hydrophilized hydrophobic fibers, such as surfactant-treated or silica-treated thermoplastic fibers. For reasons of availability and cost, cellulose fibers, in particular wood pulp fibers which are also referred to as airfelt, are preferred.

As used herein, the term "hydrophilic" describes fibers or the surfaces of fibers which are wetted by the liquids deposited onto the fibers. The state of the art respecting wetting of materials allows definition of hydrophilicity (and wetting) in terms of contact angles and the surface tension of the liquids and solids Invovled. This is discussed in detail in The American Chemical Society publication entitled *Contact Angle, Wetability, and Adhesion* edited by Robert F. Gould and copyrighted in 1964. A fiber or surface of a fiber is said to be wetted by a liquid either when the contact angle between the liquid and the fiber or surface is less than 90° or when the liquid will tend to spread spontaneously across the surface; both conditions normally coexist.

In addition to hydrophilic fibrous material, the absorbent member **42** also contains particular amounts of discrete particles of absorbent gelling material. Such absorbent gelling material may be inorganic or organic compounds capable of absorbing liquids and retaining them under moderate pressures.

Suitable absorbent gelling materials can be inorganic materials such as silica gels or organic compounds such as cross-linked polymers. Cross-linking may be by covalent, ionic, van der Waals, or hydrogen bonding. Examples of absorbent gelling material polymers include polyacrylamides, polyvinyl alcohol, ethylene maleic anhydride copolymers, polyvinyl ethers, hydroxypropyl cellulose, carboxymethyl cellulose, polyvinylmorpholinone, polymers and copolymers of vinyl sulfonic acid, polyacrylates, polyacrylamides, polyvinyl pyridine and the like. Other suitable hydrogels are disclosed in Assarson et al., U.S. Pat. No. 3,901,236 issued Aug. 26, 1975, which patent is incorporated herein by reference. Particularly preferred polymers for use in the absorbent member are hydrolized, acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates and isobutylene maleic anhydride copolymers, or mixtures thereof.

Processes for preparing hydrogels are disclosed in Masuda et al., U.S. Pat. No. 4,076,663, issued Feb. 28, 1978; Tsubakimoto et al. U.S. Pat. No. 4,286,082, issued Aug. 25, 1981; and further in U.S. Pat. Nos. 3,734,876, 3,661,815, 3,670,731, 3,664,343, 3,783,871 and Belgium Pat. No. 785,850, which patents are all incorporated herein by reference.

Absorbent gelling material used in the absorbent member **42** is in the form of discrete "particles". Particles of absorbent gelling material can be of any desired shape, e.g., spiral or semi-spiral, cubic, rod-like, polyhedral, etc. Shapes having a large greatest dimension/smallest dimension ratio, like needles, flakes, and fibers, are also contemplated for use herein. Conglomerates of

particles of absorbent gelling material may also be used in the absorbent member **42**.

Although the absorbent gelling material-containing absorbent member is expected to perform well with particles having a size varying over a wide range, other considerations may preclude the use of very small or very large particles. For reasons of industrial hygiene, average particle sizes smaller than about 30 microns are less desirable. Particles having a smallest dimension larger than about 2 millimeters may also cause a feeling of grittiness in the absorbent member, which is undesirable from a consumer aesthetics standpoint. Furthermore, the rate of fluid absorption is affected by particle size. Larger particles have very much reduced rates of absorption. Preferred for use herein are particles having an average size of from about 50 microns to about 1 millimeter. "Particle size" as used herein means the weighted average of the smallest dimension of the individual particles.

Although most absorbent gelling materials will perform well in the absorbent member **42** of the present invention, absorbent gelling materials having high gel strength are particularly useful. Gel strength must be such that the particles of absorbent gelling material do not deform and fill to an unacceptable degree the capillary void space in the absorbent member **42**, thereby inhibiting both absorbent capacity of the structure and fluid distribution throughout the structure.

Gel strength refers to the tendency of the particles of absorbent gelling material to deform or spread under stress once the particles absorb liquids. For a given type of absorbent gelling material, gel strength will generally decrease as the gel volume increases. It has been found that it is desirable to utilize an absorbent member **42** whose polymer materials have as high a gel strength as possible consistent with the realization of absorbent gelling materials of acceptably high gel volume.

It has been found that gel strength, i.e. gel deformation tendency, (in the context of absorbent gelling materials incorporated into absorbent members and absorbent articles) correlates directly with the shear modulus of the absorbent gelling material. Accordingly, polymer materials of absorbent gelling material having sufficient gel strength can be appropriately characterized by specifying gel strength in terms of the shear modulus of the particles of absorbent gelling material.

Shear modulus can be conventionally measured, for example, by a procedure which involves the use of a stress rheometer to determine the ratio of (a) stress applied to a given sample versus (b) the resulting strain exhibited by the sample. The absorbent gelling material sample tested in this manner is swollen to its gel volume with synthetic urine. Using a procedure described in greater detail hereinafter, the stress/strain ratio is determined. The shear modulus of the resulting sample in dynes/cm^2 is then subsequently calculated from this ratio. Absorbent gelling materials which have been found to be particularly useful in the present invention exhibit a shear modulus of at least about 2,000 dynes/cm^2. More preferably, the absorbent gelling materials have a shear modulus within the range of about 2500 to about 92,000 dynes/cm^2 and most preferably of from about 5,000 to about 35,000 dynes/cm^2.

Without wishing to be bound by any particular theory, it is believed that absorbent gelling materials having high gel strength as reflected in their shear modulus values will resist deformation upon fluid absorption and will have a reduced tendency to flow into the void spaces between fibers. Thus, high gel strength absorbent gelling materials may actually serve to maintain separation of the individual fibers of the hydrophilic fibrous material. Such fiber separation improves both the wicking and the absorbent capacity of such absorbent members. Low gel strength materials, on the other hand, merely flow into the void spaces between the fibers upon fluid absorption and can thereby actually reduce the acquisition rate and the absorbent capacity of the absorbent members and absorbent articles into which they are incorporated.

Gel strength of absorbent gelling materials is quantified by means of determining the shear modulus of a sample of the swollen particles. Shear modulus is determined using a stress rheometer which comprises a circular lower plate onto which the swollen particle sample is placed. A truncated conical upper element having the same projected surface area as the area of the lower circular plate is positioned above the circular lower plate. This upper element is lowered into the mass of swollen particle material on the circular lower plate and is positioned at the proper gap relative to the circular lower plate. This gap corresponds to the point at which an untruncated cone would contact the lower plate.

An oscillating torque (stress) is applied torsionally to the conical element, and the resulting angular displacement of the cone is determined as a function of the applied torque.

The sample being tested is swollen to its gel volume in synthetic urine. Synthetic Urine is typically 15.0 parts of 1% Triton X-100, 60.0 parts of NaCl, 1.8 parts of $CaCl_2 \cdot 2H_2O$, and 3.6 parts of $MgCL_2 \cdot 6H_2O$, diluted to 6000 parts with distilled H_2O. The resulting solution has an absorbance of about 0.25 at its absorbence maximum of 617 mm.

Excess free synthetic urine is removed from the sample by blotting, and approximately 1.5 cc of the swollen material is placed in the gap between the lower circular plate and the upper conical element of the rheometer. This mass is usually formed from an agglomeration of swollen particles which have unswollen particle dimensions less than 710 microns. Spherical particles should be ground to form irregular shaped particles before testing.

Stress and strain measurements are taken under the following conditions:

Parameter	Value
Type of Rheometer	Sangamo Visco-elastic Analyzer
Configuration	Oscillating Cone and Plate
Plate Radius	2.5 cm
Cone Radius (Edge to vertex)	2.5 cm
Cone Angle*	43.6 milliradians
Oscillation Frequency	1.0 Hertz
Strain Amplitude	2.5%
Sample Temperature	21.4° C.

*Angle between surface of the lower plate and the surface of the cone i.e. (Pi/2 - semi-vertical angle).

Under these conditions, an oscillatory torque (stress) is applied via the upper conical element to the swollen particles. This results in an oscillatory response (strain) of the sample which is reflected by the magnitude of the angle through which the conical element rotates in response to the applied torque. The shear modulus of the particles is calculated from the ratio of (i) the applied stress to (ii) the amplitude of the in-phase component of the resultant strain.

For the particular cone/plate geometry employed in this testing, the ratio of stress (g-cm) to strain (milliradians) is converted to shear modulus (dynes/cm^2) using the following formula:

$$\text{Shear modulus} = \frac{3 \times 981 \times \text{Cone Angle} \times \text{Cos(Phase Angle)} \times \text{Torque}}{2 \times Pi \times \text{Plate Radius}^3 \times \text{Strain}}$$

wherein the cone angle and strain are expressed in units of milliradians, the plate radius in units of cm and torque in units of g-cm. For absorbent gelling materials, the phase angle is close to zero and so the cosine of the phase angle is taken as unity. The factor **981** is that which converts g-cm to dyne-cm. Thus

$$\text{Shear Modulus (dynes/cm}^2) = 1308 \times \frac{\text{Torque (gm-cm)}}{\text{Strain (milliradians)}}$$

for the particular equipment used in this test method.

The relative amount of hydrophilic fibrous material and particles of absorbent gelling material used in the absorbent member **42** of the present invention can be most conveniently expressed in terms of a weight percentage of the absorbent member **42**. The absorbent member **42** preferably contains from about 2% to about 60%, more preferably from about 10% to about 25% by weight, of the absorbent member **42** of absorbent gelling material. This concentration of absorbent gelling material can also be expressed in terms of a weight ratio of fiber to particulate. These ratios may range from about 40:60 to about 98:2. For most commercially available absorbent gelling materials, the optimum fiber-to-particulate weight ratio is in the range of from about 50:50 to about 91:9. Based on a cost/performance analysis, ratios of from about 75:25 to about 90:10 are most preferred for use in the absorbent member **42**.

In addition, the particles of absorbent gelling material may be dispersed in various weight ratios throughout different regions and thicknesses of the absorbent member **42**.

For example, the mixture of hydrophilic fibrous material and particles of absorbent gelling material may be disposed only in the deposition region **54** of the absorbent member **42** and not in the back section **48** or the end region **52**. In addition, the acquisition zone **56** need not comprise the fiber/particulate mixture. While an acquisition zone **56** containing only hydrophilic fibrous material may work satisfactorily in rapidly acquiring liquids, such an embodiment is not preferred. When particles of an absorbent gelling material are maintained in the acquisition zone **56**, especially high gel strength absorbent gelling materials, the particles help maintain an open capillary structure when the acquisition zone **56** is wetted so as to enhance planar transport of liquids away from the acquisition zone **56** to the rest of the absorbent member **42**. Thus, the acquisition zone **56** preferably contains a uniformly distributed mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material. It is most preferred that the particles are substantially uniformly dispersed throughout the entire absorbent member **42**.

The deposition region **54** comprises an acquisition zone **56** and a storage zone **58** in liquid communication with at least a portion of the acquisition zone **56**. The acquisition zone **56** comprises portions of the deposition region **54** designated by the dotted lines in FIG. **4**. The storage zone **58** generally comprises the remainder of the deposition region **54** and more preferably the remainder of the absorbent member **42**.

It has been found that a relative capillarity difference between the acquisition zone **56** and the storage zone **58** is of importance in the overall efficiency and effectiveness of the absorbent member **42**. While liquid capillarity can be defined in several ways (e.g., pore size, density, basis weight, etc.), the density and basis weight of the structure are the preferred parameters to define liquid capillarity in the absorbent member **42** of the present invention. Thus, the acquisition zone **56** must have both a relatively lower average density and lower average basis weight per unit area than the storage zone **48** to establish the preferred capillary force gradient between them. Thus, the ratio of the average density of the storage zone **58** to the average density of the acquisition zone **56** should preferably be about equal to or greater than about 1.25:1, more preferably about 1.5:1 and most preferably about 2:1.

Without wishing to be bound by theory, it is believed that the differential lower capillarity, the lower average density and lower average basis weight, of the acquisition zone **56** in comparison to the storage zone **58** is significant in achieving both a more optimized liquid acquisition rate into the absorbent member **42** and a relatively high liquid planar wicking rate throughout the absorbent member **42**. When an absorbent member **42** having a mixture of hydrophilic fibrous material and particles of absorbent gelling material is densified to the densities approximating those of the storage zone **58**, the liquid planar wicking rate becomes much faster. It is believed that densifying the absorbent member **42** results in better planar wicking of liquid throughout the absorbent member **42** (the x-y direction) because of the higher capillary force due to the smaller pore size of the densified fibers. Densifying the absorbent member **42** further results in a reduction in the bulk of the structure (which is desirable from a consumer standpoint for aesthetic reasons).

However, the densification of the absorbent member **42** also results in a reduction in the rate of liquid acquisition into the absorbent member **42** in the direction normal to planar wicking (i.e. the z-direction). It is believed that as higher concentrations of absorbent gelling material are located in the area of typical liquid deposition, a maximum gel blocking effect is achieved, thereby reducing the liquid acquisition rate. Thus, it is important to provide a means for delivering the liquid into the absorbent member **42** at a high rate. The acquisition zone **56** of lower average density and lower average basis weight per unit area than the densified absorbent member **42** or storage zone **58** provides such a means. The acquisition zone **56** has a smaller concentration of particles of absorbent gelling material in the area of typical liquid deposition, thereby reducing the incidence of gel blocking in this area during the liquid acquisition phase and thus improving the liquid acquisition rate.

The capillary force gradient created at the interface between the acquisition zone **56** and the storage area **58** also improves the containment characteristics of the absorbent member **42**. Liquids deposited on the acquisition zone **56** tend to be acquired quickly into the structure by the action of the acquisition zone **56**. Because the storage zone **58** has a higher capillarity than the acquisition zone **56**, the acquired liquids tend to be drawn into the storage zone **58** and are then delivered to

the other portions of the storage zone **58** by the enhanced planar wicking rate achieved in the storage zone **58**; the liquids being retained even under moderate pressure by the particles of absorbent gelling material in the storage zone **58**. Thus, it has been found that an absorbent member **42** having an acquisition zone **56** having a lower average density and lower average basis weight per unit area than the storage zone **58** improves leakage containment by more quickly acquiring and distributing liquids into and throughout the absorbent member **42**.

In addition, it is believed that the acquisition zone **56** provides an additional mechanism whereby an absorbent member **42** that has already been wetted may contain and more readily acquire further discharged liquids. A property of the particles of absorbent gelling material is that they expand when wetted. Thus when the absorbent member **42** is wetted, the particles of absorbent gelling material in both the acquisition zone **56** and the storage zone **58** expand. However, because there is a greater concentration of particles of absorbent gelling material in the higher average density and higher average basis weight storage zone **58**, the storage zone **58** tends to expand to a greater thickness than the acquisition zone **56**. Thus, if the acquisition zone **56** is laterally surrounded by the storage zone **58**, a well or hole effect is created. This "well" is advantageous for second depositions of liquids because the liquids will tend to be drawn into the well because it is in effect a zero density acquisition area. This is especially helpful in the case of diapers for overnight use wherein the wearer sleeps on the stomach because gravity additionally tends to pull the later discharged liquids into the well whereupon they distribute into the acquisition zone **56** and are wicked into the storage zone **58**. Thus, the acquisition zone **56** provides an additional advantage for wetted absorbent members.

The storage zone **58** is thus the relatively high capillarity (high density and high basis weight) portion of at least the deposition region **54**. The primary functions of the storage zone **58** are to absorb discharged liquids that are either deposited directly onto the storage zone **58** or transferred to the storage zone **58** via the capillary force gradients established between the acquisition zone **56** and the storage zone **58**, and to retain such liquids under the pressures encountered as a result of the wearer's movements. Preferably, the storage zone **58** consists essentially of the structure disclosed in European Patent Application EP-A-122,042 or the lower fluid storage layer disclosed in United States patent application Ser. No. 734,426, both of which are incorporated herein by reference, although other high capillarity structures may also be used.

The storage zone **58** preferably has a relatively high density and a high basis weight in relation to the acquisition zone **56**. The density and basis weight values of the storage zone **58** include the weight of the particles of absorbent gelling material, such that the density and basis weight values will vary depending upon the amount of particles dispersed throughout the absorbent member **42**. Thus, the storage zone **58** will generally have a density of from about 0.06 to about 0.4 g/cm^3, and more preferably within the range of from about 0.09 to about 0.20 g/cm^3 for an absorbent member **42** containing about 15% by weight of particles of absorbent gelling material. The basis weight of such a storage zone **58** can range from about 0.02 to about 0.186 g/cm^2, preferably from about 0.038 to about 0.12 g/cm^2. For an absorbent member **42** containing about 50% by weight of particles of absorbent gelling material, the density will typically range from about 0.1 to about 0.68 g/cm^3 with a basis weight from about 0.034 to about 0.31 g/cm^2. The density of the storage zone **58** is calculated from its basis weight and caliper measured on newly unpacked, unfolded and dissected diapers. The caliper is measured using a standard guage with the sample under a "gentle" load of 10 g/cm^2. The basis weight is measured by die-cutting a certain size sample and weighing the sample on a standard scale, the weight and area of the sample determining the basis weight. (It should be noted that the density and basis weight values include the weight of the particles of absorbent gelling material.)

While the storage zone **58** may take on a number of sizes and shapes, it is preferred that the storage zone **58** comprises the portion of at least the deposition region **54** wherein there is no acquisition zone **56**. (i.e. The entire deposition region **54** comprises a storage zone **58** except for the acquisition zone **56**.) While the back section **48** and the end region **52** need not comprise storage zones, in the particularly preferred embodiments of the absorbent member **42** as shown in FIGS. **2**, **3** and **4**, the entire absorbent member **42** except for the acquisition zone **56** consists of one or more storage zones **58**. In addition, while the storage zone **58** need not completely laterally surround the acquisition zone **56** (i.e. it is in liquid communication with at least a portion of the lateral area of the acquisition zone **56**), in preferred embodiments of the present invention, the storage zone **58** laterally surrounds the acquisition zone **56** so as to take full advantage of the capillarity difference between them.

The acquisition zone **56** has a relatively lower capillarity and thus preferably a lower average density and a lower average basis weight per unit area than the storage zone **58**. The acquisition zone **56** serves to quickly collect and temporarily hold discharged liquids. Since such liquids are generally discharged in gushes, the acquisition zone **56** must be able to quickly acquire and transport liquid by wicking from the point of liquid contact to other parts of the absorbent member **42**. The acquisition zone **56** preferably has a density of from about 0.03 to about 0.24 g/cm^3, more preferably from about 0.05 to about 0.15 g/cm^3 for an absorbent member **42** containing about 15% by weight of particles of absorbent gelling material. The basis weight of such an acquisition zone **56** will preferably range from about 0.015 to about 0.1 g/cm^2 and more preferably from about 0.018 to about 0.06 g/cm^2. For an absorbent member **42** containing about 50% by weight of particles of absorbent gelling material, the density will typically range from about 0.05 to about 0.41 g/cm^3 with a basis weight of from about 0.025 to about 0.17 g/cm^2. The density of the acquisition zone **56** is calculated from its basis weight and caliper measured on newly unpacked, unfolded and dissected diapers. The caliper is measured using a standard guage with the sample under a "gentle" load of 10 g/cm^2. The basis weight is measured by die-cutting a certain size sample and weighing the sample on a standard scale, the weight and area of the sample determining the basis weight. (The density and basis weight values include the weight of the particles of absorbent gelling material.)

While the acquisition zone **56** may conceivably have density and basis weight values equal to zero, i.e. a hole or void space, such an embodiment is not as preferred as an acquisition zone **56** having some minimal value of

density and basis weight. The transfer of liquids through the topsheet **38** has been found to be diminished in an absorbent member **42** having an acquisition zone **56** of zero density and basis weight due to the lack of intimate contact between any fibers of the acquisition zone **56** and the topsheet **38**. Thus, liquid may tend to pool or collect on the topsheet **38** thereby creating a wet feeling for the wearer. Thus, it is preferred that the acquisition zone **56** have some minimum density and basis weight.

While the density and basis weight of the acquisition zone **56** may vary throughout its area and thickness, such an embodiment is also not preferred. The acquisition zone **56** preferably has a substantially uniform density and uniform basis weight throughout its area and thickness. This uniform density and basis weight provides a uniform capillary force gradient across the interface between the acquisition zone **56** and the storage zone **58** that provides even liquid transfer.

The shape, size and positioning of the acquisition zone **56** is of importance in determining the effectiveness of the resulting absorbent member **42** in rapidly acquiring discharged liquids. In accordance with the present invention, the acquisition zone **56** should be placed in a specific positional relationship with respect to the area of typical liquid deposition of the absorbent member **42**. While portions of the acquisition zone **56** may be positioned in the back section **48** of the absorbent member **42**, the acquisition zone **56** is preferably positioned generally in the front section **50** of the absorbent member **42** so that the acquisition zone **56** is positioned in the area of typical liquid deposition, i.e. the deposition region **54**. Thus, the acquisition zone **56** is placed in the vicinity of the point of discharge of liquids so as to be capable of quickly acquiring such liquids at their contact zone.

The generally forward positioning of the acquisition zone **56** can be defined by specifying the percentage of the top surface area of the acquisition zone **56** which is found forward of particular points along the length of the absorbent member **42**. While the positioning of the acquisition zone **56** can alternatively be defined with respect to the volume of the acquisition zone positioned forward of particular points, it has been found that the top surface area of the acquisition zone **56** is a more desirable definition because the top surface area actually defines the initial area available for liquid acquisition. In addition, since the thickness of the absorbent member **42** is preferably uniform in the deposition region **54** and the acquisition zone **56** has a generally rectangular cross-sectional area, the top surface area definition is equal to a volumetric definition in a preferred embodiment. Thus, the positioning of the acquisition zone **56** will be referenced throughout the specification as related to its top surface area. (i.e. The percentage of the top surface area of the acquisition zone positioned in a given area.)

Thus, in accordance with the present invention, at least a portion of the acquisition zone **56** must be placed in the deposition region **54**, even though the remaining portion may be positioned anywhere in the absorbent member **42** including the back section **48** and the end regions **52**. (It being understood that if plural acquisition zones are utilized, at least a portion of one of the acquisition zones must be positioned in the deposition region **54**.) However, the acquisition zone **56** is preferably positioned relative to the absorbent member **42** such that the top surface area of the acquisition zone **56** is completely positioned within the front section **50** of the absorbent member **42**. More preferably, the acquisition zone **56** is positioned relative to the absorbent member **42** such that the top surface area of the acquisition zone **56** is completely positioned within the deposition region **54** of the absorbent member **42**. Even more preferably, at least 30% of the top surface area of the acquisition zone **56** is positioned in the front half of the front section (approximately the front ⅓ of the overall absorbent member **42**) of the absorbent member **42**.

The forward positioning of the acquisition zone **56** may alternatively be defined by specifying the percentage of the top surface area of the acquisition zone **56** that is found forward of particular points along the length of the diaper **20** or other absorbent article. Thus, the acquisition zone **56** is preferably positioned on the absorbent member **42** relative to the backsheet **40** such that at least a portion of the top surface area of the acquisition zone **56** is in the crotch region **26** of the diaper **20**. More preferably, the acquisition zone **56** is positioned such that its top surface area is completely positioned in the front two-thirds portion of the diaper **20**, most preferably in the front half portion of the diaper **20**; the top surface area also most preferably being completely positioned in the crotch region **26** of the diaper **20**. (As noted herein, "portions" of the diaper **20** or other absorbent article can be defined by reference to the top surface area of the unfolded diaper **20** or absorbent article found in front of a given point on the line which defines the length of the diaper **20**).

For purposes of determining the positioning of such acquisition zone **56**, the length of the absorbent member **42** or diaper **20** will be taken as the normal longest longitudinal dimension of the elongated structure. This normal longest dimension can be defined with respect to the structure as it is applied to the wearer. When worn, the opposing ends of the backsheet are fastened together so that the ends form a circle around the wearer's waist. The normal length of the absorbent member **42** or diaper **20** will thus be the length of the line running through the absorbent member **42** or diaper **20** from the point on the edge of it at the middle of the wearer's back waist, through the crotch, to the point on the opposite edge of the absorbent member **42** or diaper **20** at the middle of the wearer's front waist.

The top surface area of the acquisition zone **56** may be found using either of two techniques. The primary and simplest way is to place the absorbent member **42** on a standard light box, such as the transluminator model manufactured by Aristo grid Lamp Products, Inc. The acquisition zone **56**, because it has a lower average density and lower average basis weight than the surrounding storage zone **58**, will appear lighter or brighter due to the fact that more light will be transmitted through the acquisition zone **56**. The acquisition zone **56** can then be mapped onto paper having grids to measure the top surface area of the acquisition zone **56**.

The alternative method comprises mapping the density profile of the absorbent member **42** to determine the top surface area of the acquisition zone **56**. The absorbent member **42** is cut into samples having small areas. The density and basis weight of each of the samples are then calculated using the techniques discussed above. Thus, the relatively lower density and lower basis weight samples are charted against the relatively higher density and higher basis weight samples to measure the top surface area of the acquisition zone **56**.

The acquisition zone **56** can be of any desired shape consistent with the absorbency requirements of the absorbent member **42** or diaper **20** including, for example, circular, rectangular, triangular, trapezoidal, oblong, hourglass-shaped, funnel-shaped, dog-bone-shaped or oval. Preferred shapes of the acquisition zone **56** are those that increase the perimeter of the interface between the acquisition zone **56** and the storage zone **58** so that the relative capillarity difference between the zones is fully utilized. In a preferred embodiment, the acquisition zone will be oval shaped having a top surface area of about 45 cm^2 (about $7in^2$).

In order to maintain a certain minimal absorbency level in the front section **50** of the absorbent member **42**, the top surface area or volume of the storage zone **58** must comprise some minimal amount of the top surface area or volume of the front section **50**. Thus, it has been found that the acquisition zone **56** should preferably comprise less than the entire top surface area and/or volume of the front section **50** of the absorbent member **42**. (Since in a preferred embodiment the acquisition zone **56** is of generally uniform thickness and cross-sectional area, volume can be interchanged with top surface area as a definitional point.) The top surface area of the portion of the acquisition zone **56** positioned in the front section **50** of the absorbent member **42** preferably comprises less than about 50% of the top surface area of the front section **50**. More preferably, the top surface area of the acquisition zone **56** comprises less than about 35% of the top surface area of the front section **50** of the absorbent member **42**, with less than about 20% being especially preferred. In addition, the top surface area of the acquisition zone **56** preferably comprises less than about 50% of the top surface area of the deposition region **54**, more preferably less than about 35%, and most preferably less than about 20%.

The acquisition zone **56** may also have a number of different cross-sectional areas and configurations including those wherein the area of portions of the acquisition zone **56** is less or greater than its top surface area (i.e., The acquisition zone **56** is smaller or wider below the top surface of the absorbent member **42**.) For example, the acquisition zone **56** may have conical, trapezoidal, T-shaped or rectangular cross-sectional areas. As shown in FIGS. **2** and **3**, the acquisition zone **56** preferably has a rectangular cross-sectional area so as to provide a uniform acquisition zone **56**.

In addition, the acquisition zone **56** need not comprise the entire thickness of the absorbent member **42**, but may extend through only a fraction of its total thickness. The acquisition zone **56** may also have a different thickness than the surrounding storage zone **58**. However, in a preferred embodiment as shown in FIGS. **2** and **3**, the acquisition zone **56** preferably extends through the entire thickness of the absorbent member **42** and has a thickness equal to the thickness of the surrounding storage zone **58** in the deposition region **54**.

While the acquisition zone **56** may be transversely positioned anywhere along the absorbent member **42**, it has been found that the acquisition zone **56** functions the most efficiently when it is transversely centered within the front section **50** or the deposition region **54** of the absorbent member **42**. Thus, the acquisition zone **56** is preferably centered about the longitudinal centerline **68** of the absorbent member **42**. More preferably, the acquisition zone **56** is transversely positioned only in the central region **64** of the front section **50** or deposition region **54** of the absorbent member **42** such that none of the acquisition zone **56** is located in the ear regions **60** and **62**.

Such an absorbent member **42** is preferably made by airlaying a thickness profiled absorbent member-preform and then calendering the absorbent member **42** in a fixed-gap calender roll to effect densifying the absorbent member **42**. The thickness profiled absorbent member **42** initially has areas of higher basis weight which define the storage zone **58** and of lower basis weight which define the acquisition zone **56**. The absorbent member **42** is then calendered preferably to at least a uniform thickness in the deposition region. Thus, a lower average density and a lower average basis weight per unit area acquisition zone **56** is created relative to the higher average density and higher average basis weight storage zone **58**. Additionally, discrete particles of absorbent gelling material are added to an air-entrained stream of fibers prior to their deposition onto the preform to affect uniform distribution of absorbent gelling material throughout the preformed absorbent member **42**. Thus, the resultant absorbent member **42** contains a uniform mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material.

In use, the diaper **20** is applied to a wearer, by positioning the back waistband region **24** under the wearer's back, and drawing the remainder of the diaper **20** between the wearer's legs so that the front waistband region **22** is positioned across the front of the wearer. The ends of the tape-tab fasteners **46** are then secured preferably to outwardly facing areas of the diaper **20**. In use, disposable diapers or other absorbent articles having such absorbent members **42** having a relatively lower average density and lower average basis weight acquisition zone **56**, tends to more quickly acquire liquids into the acquisition zone **56** and to distribute these liquids to the remaining portions of the absorbent member **42** and to remain dry or dryer due to the preferential capillarity between the storage zone and the acquisition zone **56** of the absorbent member **42**. Thus, such an absorbent member **42** helps to alleviate leakage around the edges of such absorbent articles.

FIG. **5** shows an alternative embodiment of an absorbent member **542** of the present invention. As shown in FIG. **5**, the front section **550** of the absorbent member **542** has a thickness, **T1**, greater than the thickness, **T2**, of the back section **548**. The acquisition zone **56** is preferably of the same thickness, **T1**, as the storage zone **58** positioned in the front section **550** of the absorbent member **542**; the front section **550** having a terraced character by virtue of the thickness difference between the front section **550** and the back section **548** and by virtue of the relatively steep slope formed by a density/-basis weight transition zone which is designated **572**. Preferably, T1 is at least about 1.5 times as great as T2 and preferably about 2.0 times as great as T2. In this preferred embodiment, about three-fourths of the absorbent material is disposed in the front section **550** of the absorbent member **542** thereby providing an absorbent member **542** wherein the front section **552** has high absorbent capacity as well as rapid acquisition characteristics.

FIGS. **6** and **7** show a further alternative embodiment of an absorbent member **642** of the present invention. An absorbent acquisition core **674** is positioned over the absorbent member **642** of the present invention to form a dual-layer absorbent core. An example of a similar dual-layer absorbent core is discussed in more detail in United States patent application Ser. No. 734,426 filed

by Paul T. Weisman, Dawn I. Houghton, and Dale A. Gellert on May 15, 1985, which is incorporated herein by reference.

The absorbent acquisition core **674** preferably consists essentially of hydrophilic fibrous material. This absorbent acquisition core **674** thus serves to quickly collect and temporarily hold discharged liquids and to transport such liquids by wicking from the point of initial contact to other parts of the absorbent acquisition core **674**. Since the primary function of the absorbent acquisition core **674** is to receive liquids passing through the topsheet **38** and to transport such liquids to other areas of the absorbent acquisition core **674** and eventually onto the absorbent member **642**, the absorbent acquisition core **674** can be substantially free of absorbent gelling material. Alternatively, the absorbent acquisition core **674** can contain particular amounts of absorbent gelling material. Thus, the absorbent acquisition core **674**, for example, can contain up to about 50%, or preferably up to about 25% or 40%, by its weight of particles of absorbent gelling material. In the most preferred embodiments, the absorbent acquisition core contains up to about 8% by its weight of particles of absorbent gelling material. In some instances, the presence of particles of absorbent gelling material in the absorbent acquisition core **674** can actually serve to maintain its density within the optimum range to promote fluid distribution. The specific type of absorbent gelling material optionally used in the absorbent acquisition core **674** does not have to be the same as the type essentially employed in the absorbent member **642**.

The shape, size and character, including capillarity of the absorbent acquisition core **674**, is of some importance in determining the effectiveness of the resulting diaper **20** or other absorbent article. The absorbent acquisition core **674** in the unfolded configuration can be of any desired shape, for example, rectangular, oval, oblong, asymmetric or hourglass-shaped. The shape of the absorbent acquisition core **674** will frequently define the general shape of the resulting diaper **20**. In preferred embodiments of the present invention as shown in FIG. 6, the absorbent acquisition core **674** will be hourglass-shaped and will be of a substantially uniform density within the range of from about 0.07 to about 0.20 g/cm^3. Preferably, the core will have a basis weight ranging from about 0.007 to about 0.075 g/cm^2.

The absorbent acquisition core **674** may alternatively comprise a core acquisition zone (not shown) having a lower average density and a lower average basis weight than the remainder of the absorbent acquisition core **674**. This core acquisition zone may have the same shape, positioning and characteristics as the acquisition zone **656** of the absorbent member **642**, or it may have different shapes, positioning and/or characteristics. Preferably, the core acquisition zone of the absorbent acquisition core **674** overlays at least a portion of the acquisition zone **656** of the absorbent member **642**, and more preferably the entire acquisition zone **656** of the absorbent member **642**, so as to provide an overall acquisition zone extending throughout the entire thickness of the dual-layer absorbent core system.

The absorbent member **642** of the present invention need not be as large as the absorbent acquisition core **674** and can, in fact, have a top surface area which is substantially smaller than the top surface area of the absorbent acquisition core **674**. Generally, the absorbent member **674** will have a top surface area from about 0.25 to about 1.0 times that of the absorbent acquisition core **674**. Most preferably, the top surface area of the absorbent member **642** will be only from about 0.25 to about 0.75, and most preferably from about 0.3 to about 0.5, times that of the absorbent acquisition core **674**.

The absorbent member **642** is preferably placed in a specific positional relationship with respect to the backsheet **40** and/or the absorbent acquisition core **674** in the diaper or other absorbent article. More particularly, the absorbent member **642** is positioned generally toward the front of the diaper so that absorbent gelling material is most effectively located to acquire and hold discharged liquids from the absorbent acquisition core **674**.

The forward postioning of the absorbent member **642** can be defined by specifying the percent of total absorbent gelling material which is found forward of particular points along the length of the diaper or other absorbent article. Thus, in accordance with the present invention, the absorbent member **642** is positioned relative to the backsheet and/or the absorbent acquisition core such that (1) at least about 75% of the total absorbent gelling material in the absorbent member **642** is found within the front two-thirds portion of the diaper or other absorbent article, and (2) at least about 55% of the total absorbent gelling material in the absorbent member **642** is found within the front half portion of the diaper or other absorbent article. More preferably, the absorbent member **642** is positioned relative to the backsheet **38** and/or the absorbent acquisition core **674** such that at least about 90% of the total absorbent gelling material in the absorbent member **642** is found in the front two-thirds portion and at least about 60% of the total absorbent gelling material is found in the front half portion of the diaper or other absorbent article. (As noted, for purposes of the present invention, "portions" of the diaper or other absorbent article can be defined by reference to the top surface area of the unfolded diaper **20** or absorbent article found in front of a given point on the line which defines the length of the diaper **20** or absorbent article).

In the usual instance when the absorbent acquisition core **674** generally defines the shape of the diaper or other absorbent article, the normal length of the backsheet **38** will be approached by the longest longitudinal dimension of the absorbent acquisition core **674**. In such instances, the positioning of the absorbent member **642** can also be defined with respect to its location toward the front portion of the absorbent acquisition core **674**. However, in some applications (e.g. adult incontinence articles) wherein bulk reduction or minimum cost are important, the absorbent acquisition core would not take on the general shape of the diaper or incontinence structure. Rather, it would be generally located to cover only the gential region of the wearer and could in this case have approximately the same top surface area as the absorbent member **642**. In this instance, both the absorbent acquisition core **674** and the co-extensive absorbent member **642** would be located toward the front of the article as defined by only the backsheet **38** such that the requisite percentages of absorbent gelling material would be found in the front two-thirds and front half sections respectively of the diaper or other absorbent article.

The absorbent member **642** of the dual-layer absorbent core can be of any desired shape consistent with comfortable fit including, for example, circular, rectangular, trapezoidal, oblong, hourglass-shaped, dog-bone-

shaped or oval. If desired, the absorbent member 642 can be wrapped in a high wet strength envelope web such as tissue paper or a synthetic fine pore, e.g., non-woven material, to minimize the potential for particles of absorbent gelling material to migrate out of the absorbent member 642. Another objective of such overwrapping is to desirably increase the in-use integrity of the dual layer absorbent core. Such a web can, in fact, be glued to the absorbent member 642. Suitable means for carrying out this gluing operation include the glue spraying procedure described in U.S. Pat. No. 4,573,986 issued to Minetola and Tucker, on Mar. 4, 1986, which patent is incorporated herein by reference.

In preferred embodiments, the absorbent member 642 of the dual layer absorbent core will be oblong. In especially preferred embodiments, an oblong absorbent member 642 overwrapped with spray-glued tissue will be employed.

Because the absorbent member 642 of the dual-layer absorbent core is generally smaller than the absorbent acquisition core 674 such that the absorbent member 642 may entirely be placed in the area of typical liquid deposition, and because the absorbent member 642 is preferably positioned in a specific positional relationship with respect to the backsheet 38 and/or the absorbent acquisition core 674, the acquisition zone 656 may be positioned anywhere in the absorbent member 642. The acquisition zone 656 is not necessarily limited to a portion of the deposition region, since in effect the entire absorbent member 642 of the dual-layer absorbent core is in the "deposition region". The acquisition zone 656 is, however, preferably positioned in a specific positional relationship with respect to the backsheet 38 and/or the absorbent acquisition core 674 of the diaper or other absorbent article. More particularly, the acquisition zone 656 should be positioned generally toward the front of the diaper at least partially in the crotch region 26 so that the acquisition zone 656 is most effectively located to quickly acquire and distribute liquids within the absorbent member 642. Thus, the positioning of the acquisition zone 656 in the diaper or other absorbent article can be defined by specifying the percentage of the top surface area (and/or volume) which is found forward of a particular point along the length of the diaper or other absorbent article. In accordance with the present invention, the acquisition zone 656 is preferably positioned relative to the backsheet 38 and/or the absorbent acquisition core 674 such that the top surface area of the acquistion zone 656 is completely positioned within the front two-thirds portion of the diaper or absorbent article. More preferably, the acquisition zone 656 is positioned relative to the backsheet 38 and/or the absorbent acquisition core 674 such that the top surface area of the acquisition zone 656 is completely positioned within the front half portion of the diaper or absorbent article and, most preferably, such that at least about 30% of the top surface area is located in the front one-third section of the diaper or absorbent article. The acquisition zone 656 is also most preferably completely positioned within the crotch region 26 of the diaper or absorbent article.

In order to maintain a certain minimal absorbency level in the front portions of the diaper or other absorbent article, it has been found that the top surface area of the acquisition zone 656 should comprise less than the entire top surface area of the absorbent member 642 of the dual-layer absorbent core. The top surface area (and/or volume) of the acquisition zone 656 preferably comprises less than about 50% of the top surface area (and/or volume) of the absorbent member 642. More preferably, the top surface area of the acquisition zone 656 comprises less than about 35% of the top surface area of the absorbent member 642 and most preferably less than about 20% of the top surface area of the absorbent member 642. All other aspects of the acquisition zone 656 may be similar to the acquisition zone 56 discussed with respect to the absorbent member 42.

FIG. 8 shows a still further alternative embodiment of an absorbent member 842 of the present invention. The absorbent member 842 has an asymmetric shape (i.e., the absorbent member 842 is not symmetrical about its transverse centerline). In addition, the ear regions 860 and 862 and the ear regions of the back section 848 preferably have a different thickness than the central region 864. Further, the density and basis weight values of the ear regions 860 and 862 and the back section 848 are different from the storage zone 858 positioned in the central region 864 by virtue of the method by which the absorbent member 842 is formed.

The ear regions 860 and 862 and the back section 848 are preferably formed with a lesser basis weight than the storage zone 858 of the central region 864 so as to hold down the cost of such absorbent members 842 because less materials are being used. The absorbent member 842 is calendered to a uniform thickness in the central region 864 and the back section 848 except for its ear regions; the storage zone 858 of the central region 864, therefore, having a greater average density than the back section 848 except for its ear regions. (It should be understood that all or portions of the back section 848 may alternatively be calendered to a lesser thickness than the central region 864 such that the back section 848 has about an equal or a greater average density than the storage zone 858.) The ear regions 860 and 862 and the ear regions of the back section 848 are preferably calendered such that they have substantially less thickness than the central region 864 and a greater average density than the storage zone 858 of the central region 864. The thickness difference between the ear regions and the central region 864 is such that the absorbent member 842 may be easily folded to a thin configuration during packaging with the ear regions overlaying the respective central region 864 and the back section 848. The ear regions are also preferably more dense than the storage zone 858 to provide an additional capillarity difference so that liquids will tend to be pulled toward the ear regions so that the total absorbent capacity of the absorbent member 842 will be utilized.

The acquisition zone 856 of the absorbent member 842 has a funnel shape. The funnel shape is defined by a generally triangular portion 884 in combination with a stem or rectangular portion 886. The triangular portion 884 is especially effective in absorbing liquids discharged by a male wearer, while the stem portion 886 is effective for a female wearer. While it is possible that the shape of the acquisition zone 856 may vary according to the type of wearer contemplated, such as only a triangular portion 884 for a male wearer and only a stem portion 886 for a female wearer, it is preferred that the acquisition zone 856 comprise both elements.

Yet another alternative to each of the embodiments of the above absorbent members of the present invention comprises varying the pore size of the fibers without necessarily varying the density of the fibers to form an acquisition zone and a storage zone. For example, fine fiber dimensions of hardwood fluff can be utilized to

advantage by substituting at least about 50%, and preferably about 80% to 100%, hardwood fluff fibers of approximately the same density as lower density softwood fluff fibers for the softwood fibers in the storage zone. This can be done because the hardwood fluff has a smaller pore size than the softwood fluff material. As result, a capillarity difference will still be obtained within the scope of the invention, even if the density of each zone is the same. Thus, for example, an absorbent member can be obtained from using a predominately softwood pulp with a fine pore structure to define the acquisition zone and a predominately hardwood fluff pulp to define the storage zone.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

What is claimed is:

1. An absorbent member having a back section and a front section contiguous with said back section, said front section having an end region and a deposition region contiguous with said end region and said back section so that said deposition region is positioned between said end region and said back section, the absorbent member comprising:

a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material;

a storage zone positioned in at least said deposition region of the absorbent member; and

an acquisition zone positioned in at least said deposition region of the absorbent member, said acquisition zone having a density and basis weight per unit area greater than zero, said acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said storage zone at least partially laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with at least a portion of the lateral area of said acquisition zone.

2. The absorbent member of claim **1** wherein said acquisition zone extends from the top surface of the absorbent member through at least a fraction of the total thickness of the absorbent member, the top surface area of said acquisition zone being completely positioned within said front section.

3. The absorbent member of claim **2** wherein the top surface area of said acquisition zone comprises less than about 50% of the top surface area of said front section.

4. The absorbent member of claim **1** wherein said acquisition zone extends from the top surface of the absorbent member through at least a fraction of the total thickness of the absorbent member, the top surface area of said acquisition zone being completely positioned within said deposition region.

5. The absorbent member of claim **4** wherein the top surface area of said acquisition zone comprises less than about 50% of the top surface area of said front section.

6. The absorbent member of claim **4** wherein the top surface area of said acquisition zone comprises less than about 35% of the top surface area of said front section.

7. The absorbent member of claim **4** wherein the top surface area of said acquisition zone comprises less than about 20% of the top surface area of said front section.

8. The absorbent member of claim **7** wherein said acquisition zone is positioned so that at least 30% of the top surface area of said acquisition zone is positioned in the front half of said front portion.

9. The absorbent member of claim **5** wherein said acquisition zone has a thickness approximately equal to the thickness of said storage zone.

10. The absorbent member of claim **9** wherein said back section has a thickness approximately equal to the thickness of said deposition region.

11. The absorbent member of claim **10** wherein said end region has a thickness approximately equal to the thickness of said deposition region.

12. The absorbent member of claim **11** wherein said acquisition zone extends through the entire thickness of the absorbent member.

13. The absorbent member of claim **12** wherein the top surface area of said acquisition zone is transversely centered within said deposition region.

14. The absorbent member of claim **13** wherein the top surface area of said acquisition zone has a generally triangular shape.

15. The absorbent member of claim **9** wherein said deposition region has a thickness greater than an about 1.5 times the thickness of said back section.

16. The absorbent member of claim **9** wherein said deposition region has a thickness greater than about 2.0 times the thickness of said back section.

17. The absorbent member of claim **16** wherein the top surface area of said acquisition zone is transversely centered within said deposition region.

18. The absorbent member of claim **17** wherein the top surface area of said acquisition zone has an oval shape.

19. The absorbent member of claim **9** wherein said front section further has two transversely spaced ear regions and a central region disposed intermediate said ear regions, said acquisition zone being positioned within said central region.

20. The absorbent member of claim **19** wherein said ear regions have a thickness substantially less than the thickness of said central region of said front portion.

21. The absorbent member of claim **20** wherein said ear regions and said central regions are demarked from each other by sufficiently abrupt thickness differences that said front section has a terraced character.

22. The absorbent member of claim **20** wherein said ear regions have a greater average density than said storage zone positioned within said central region.

23. The absorbent member of claim **13** wherein the top surface area of said acquisition zone has a funnel shape.

24. The absorbent member of claim **13** wherein the absorbent member has an asymmetrical shape.

25. The absorbent member of claim **24** wherein the average density of said back section is less than the average density of said storage zone of said deposition region.

26. The absorbent member of claim **25** wherein the top surface area of said acquisition zone has a generally triangular shape.

27. The absorbent member of claim **1** wherein the ratio of the average density of said storage zone to the average density of said acquisition zone is about equal to or greater than 1.25:1.

28. The absorbent member of claim **1** wherein the ratio of the average density of said storage zone to the

average density of said acquisition zone is about equal to or greater than 2:1.

29. The absorbent member of claim **28** wherein the density of said acquisition zone is from about 0.05 to about 0.15 grams/cm^3.

30. The absorbent member of claim **29** wherein said acquisition zone has a substantially uniform density and uniform basis weight throughout.

31. The absorbent member of claim **1** wherein only said deposition region has discrete particles of absorbent gelling material dispersed therein.

32. The absorbent member of claim **1** wherein said mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material has a fiber-to-particulate weight ratio of from about 40:60 to about 98:2.

33. The absorbent member of claim **1** wherein said mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material has a fiber-to-particulate weight ratio of from about 50:50 to about 91:9.

34. The absorbent member of claim **33** wherein said particles of absorbent gelling material have a gel strength such that said particles have a shear modulus of at least about 2000 dynes/cm^2.

35. The absorbent member of claim **33** wherein said hydrophilic fibrous material and said discrete particles of absorbent gelling material are uniformally dispersed with respect to each other throughout the absorbent member.

36. An absorbent article comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet; and

an absorbent member according to claims **1**, **2**, **4**, **9**, **12**, **16**, **18**, or **24** positioned between said topsheet and said backsheet.

37. An absorbent member having a back section and a front section contiguous with said back section, said front section having an end region and a deposition region contiguous with said end region and said back section so that said deposition region is positioned between said end region and said back section, the absorbent member comprising:

a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material;

a storage zone positioned in at least said deposition region of the absorbent member; and

an acquisition zone positioned in at least said deposition region of the absorbent member, said acquisition zone having a larger average pore size of the fibers than said storage zone, said storage zone at least partially laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with at least a portion of the lateral area of said acquisition zone.

38. An absorbent article having a front waistband region, a back waistband region, and a crotch region disposed between said front waistband region and said back waistband region, said absorbent article comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet; and

an absorbent member positioned between said topsheet and said backsheet, said absorbent member comprising a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material; a storage zone positioned in at least said crotch region of said absorbent article; and an acquisition zone positioned in at least said crotch region of said absorbent article, said acquisition zone having a density of from about 0.05 g/cm^3 to about 0.41 g/cm^3, said acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said acquisition zone extending from the top surface of the absorbent member through at least a fraction of the total thickness of the absorbent member, the top surface area of said acquisition zone comprising less than about 35% of the top surface area of said absorbent member, said storage zone laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with the lateral area of said acquisition zone.

39. The absorbent article of claim **38** wherein said absorbent member has a uniform thickness and said acquisition zone extends through the entire thickness of said absorbent member.

40. The absorbent article of claim **39** additionally comprising an absorbent acquisition core positioned between said topsheet and said absorbent member.

41. The absorbent article of claim **40** wherein said absorbent member is generally oblong and has a top surface area that is from about 0.25 to about 1.0 times that of said absorbent acquisition core, said absorbent member being positioned relative to said backsheet and said absorbent acquisition core in a manner such that at least 75% of the absorbent gelling material in said absorbent member is found within the front two-thirds portion of the absorbent article.

42. The absorbent article of claims **38**, **40**, or **41** wherein said acquisition zone is positioned relative to said backsheet such that the top surface area of said acquisition zone is completely positioned within the front two-thirds section of the absorbent article.

43. The absorbent article of claim **41** wherein said acquisition zone is positioned relative to said backsheet such that the top surface area of said acquisition zone is completely positioned within the front one-half section of the absorbent article.

44. The absorbent article of claim **43** wherein the top surface area of said acquisition zone is completely positioned within said crotch region.

45. The absorbent article of claim **41** wherein said absorbent acquisition core has a core acquisition zone having a lower average density and a lower average basis weight than the remainder of said absorbent acquisition core.

46. The absorbent article of claim **45** wherein said core acquisition zone of said absorbent acquisition core overlays at least a portion of said acquisition zone of said absorbent member.

47. The absorbent article of claim **46** wherein said absorbent acquisition core contains particles of absorbent gelling material in an amount up to about 50% by weight of said absorbent acquisition core.

48. An absorbent core comprising:

an absorbent member comprising a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material, a storage zone, and an acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said acquisition zone having a density of from about 0.05 to about 0.41 g/cm^3, said storage zone at least partially laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with at least a

portion of the lateral area of said acquisition zone; and

an absorbent acquisition core positioned adjacent said absorbent member, said absorbent acquisition core comprising hydrophilic fibers that are substantially free of absorbent gelling material, said absorbent acquisition core having a core acquisition zone having a lower average density and a lower average basis weight per unit area than the remainder of said absorbent acquisition core, said core acquisition zone being positioned with respect to said acquisition zone of said absorbent member so as to provide an overall acquisition zone throughout the entire thickness of the absorbent core.

49. The absorbent core of claim **48** wherein said core acquisition zone has the same shape as said acquisition zone of said absorbent member.

50. The absorbent core of claims **48** or **49** wherein said absorbent member and said absorbent acquisition core are a continuous web of fibrous material.

51. The absorbent core of claim **50** wherein said overall acquisition zone is funnel-shaped.

52. The absorbent core of claim **50** wherein said overall acquisition zone has a generally triangular shape.

53. An absorbent member having a back section and a front section contiguous with said back section, said front section having an end region and a deposition region contiguous with said end region and said back section so that said deposition region is positioned between said end region and said back section, the absorbent member comprising:

a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material;

a storage zone positioned in at least said deposition region of the absorbent member; and

an acquisition zone positioned in said deposition region of the absorbent member, said acquisition zone having a density of from about 0.03 to about 0.15 g/cm^3; said acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said acquisition zone extending from the top surface of the absorbent member through the entire thickness of the absorbent member, the top surface area of said acquisition zone being completely positioned within said deposition region and comprising less than about 35% of the top surface area of said deposition region, said storage zone laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with the lateral area of said acquisition zone.

54. The absorbent member of claim **53** wherein the absorbent member has a uniform thickness.

55. The absorbent member of claim **54** wherein the absorbent member comprises a substantially uniform mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material distributed throughout the absorbent member.

56. The absorbent member of claim **55** wherein said acquisition zone has a rectangular cross-sectional area.

57. The absorbent member of claim **56** wherein the ratio of the average density of said storage zone to the average density of said acquisition zone is about equal to or greater than 1.25:1.

58. The absorbent member of claim **57** wherein said mixture of hydrophilic fibrous material and said particles of absorbent gelling material are disposed in the absorbent member in a fiber-to-particulate weight ratio of from about 40:60 to about 98:2.

59. The absorbent member of claim **58** wherein said back section has less average basis weight per unit area than said storage zone positioned in said deposition region.

60. The absorbent member of claim **59** wherein the top surface area of said acquisition zone has a generally triangular shape.

61. The absorbent member of claim **60** wherein the absorbent member has an asymmetric shape.

62. The absorbent member of claim **61** wherein the top surface area of said acquisition zone comprises less than about 20% of the top surface area of said deposition region.

63. The absorbent member of claim **62** wherein the ratio of the average density of said storage zone to the average density of said acquisition zone is about equal to or greater than 1.5:1.

64. The absorbent member of claim **58** wherein the top surface area of said acquisition zone has an hourglass shape.

65. The absorbent member of claim **58** wherein said acquisition zone comprises plural acquisition zones.

66. An absorbent article comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet; and

an absorbent member according to claims **53**, **54**, **55**, **57**, **58**, **60**, **61**, **63**, **64** or **65** positioned between said topsheet and said backsheet.

67. An absorbent member having a back section and a front section contiguous with said back section, said front section having an end region and a deposition region contiguous with said end region and said back section so that said deposition region is positioned between said end region and said back section, the absorbent member comprising:

a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material;

a storage zone positioned in at least said deposition region of the absorbent member; and

an acquisition zone positioned in said deposition region of the absorbent member, said acquisition zone having a density of from about 0.05 to about 0.41 g/cm^3, said acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said acquisition zone extending from the top surface of the absorbent member through a fraction of the total thickness of the absorbent member, the top surface area of said acquisition zone being completely positioned within said deposition region and comprising less than about 35% of the top surface area of said deposition region, said storage zone laterally surrounding the perimeter of said acquisition zone so as to be in liquid communication with the lateral area of said acquisition zone.

68. The absorbent member of claim **67** wherein said storage zone and said acquisition zone have the same thickness.

69. The absorbent member of claim **68** wherein the absorbent member has a uniform thickness.

70. The absorbent member of claim **69** wherein said back section does not comprise said storage zone.

71. The absorbent member of claim **70** wherein only said storage zone comprises said mixture of hydrophilic

fibrous material and discrete particles of absorbent gelling material.

72. The absorbent member of claim **70** wherein only said storage zone and said acquisition zone comprise said mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material.

73. The absorbent member of claim **72** wherein the top surface area of said acquisition zone has a generally triangular shape.

74. The absorbent member of claim **73** wherein the absorbent member has an asymmetric shape.

75. An absorbent article comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet; and

an absorbent member according to claims **67**, **69**, **72**, **73** or **74** positioned between said topsheet and said backsheet.

76. A disposable diaper comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet;

an absorbent member according to claims **1**, **48**, **53** or **67** positioned between said topsheet and said backsheet; and

an elastic member disposed along each longitudinal edge of said disposable diaper.

77. An absorbent core comprising:

an absorbent member comprising a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material; and

an absorbent acquisition core positioned adjacent said absorbent member, said absorbent acquisition core comprising a mixture of hydrophilic fibrous material and up to about 8% by weight of said absorbent acquisition core of discrete particles of absorbent gelling material; a storage zone positioned in at least a portion of said absorbent acquisition core; and a core acquisition zone positioned in said absorbent acquisition core, said core acquisition zone having a density and basis weight per unit area greater than zero, said core acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said core acquisition zone extending from the top surface of the absorbent member through the entire thickness of the absorbent acquisition core, the top surface area of said core acquisition zone comprising less than about 35% of the top surface area of said absorbent acquisition core, said storage zone laterally surrounding the perimeter of said core acquisition zone so as to be in liquid communication with the lateral area of said core acquisition zone.

78. An absorbent article having a front region, a back region, and a crotch region disposed between said front region and said back region, said absorbent article comprising:

a liquid pervious topsheet;

a liquid impervious backsheet associated with said topsheet;

an absorbent member comprising a mixture of hydrophilic fibrous material and discrete particles of absorbent gelling material; and

an absorbent acquisition core positioned between said topsheet and said absorbent member, said absorbent acquisition core comprising a mixture of hydrophilic fibrous material and up to about 8% by weight of said absorbent acquisition core of discrete particles of absorbent gelling material; a storage zone positioned in at least said crotch region of said absorbent article; and a core acquisition zone positioned in said crotch region of said absorbent article, said core acquisition zone having a density and basis weight per unit area greater than zero, said core acquisition zone having a lower average density and a lower average basis weight per unit area than said storage zone, said core acquisition zone extending from the top surface of the absorbent member through the entire thickness of the absorbent member, the top surface area of said core acquisition zone comprising less than about 35% of the top surface area of said absorbent member, said storage zone laterally surrounding the perimeter of said core acquisition zone so as to be in liquid communication with the lateral area of said core acquisition zone.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,834,735

DATED : May 30, 1989

INVENTOR(S) : MIGUEL ALEMANY AND CHARLES J. BERG

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10, Line 34,	"absorbance" should read ---absorbence---.
Column 14, Line 7,	"guage" should read ---gauge---.
Column 14, Line 58,	"guage" should read ---gauge---.
Column 20, Line 15,	"postioning" should read ---positioning---.
Column 20, Line 55,	"gential" should read ---genital---.
Title page, Assignee,	"Proctor" should read ---Procter---.

Signed and Sealed this

Twenty-seventh Day of March, 1990

Attest:

JEFFREY M. SAMUELS

Attesting Officer *Acting Commissioner of Patents and Trademarks*

United States Patent [19]

Angstadt

[11] **Patent Number: 4,888,231**

[45] **Date of Patent: Dec. 19, 1989**

[54] **ABSORBENT CORE HAVING A DUSTING LAYER**

[75] Inventor: **John J. Angstadt,** Cincinnati, Ohio

[73] Assignee: **The Procter & Gamble Company,** Cincinnati, Ohio

[21] Appl. No.: **68,598**

[22] Filed: **Jun. 30, 1987**

Related U.S. Application Data

[63] Continuation of Ser. No. 868,217, May 28, 1986, abandoned.

[51] **Int. Cl.**[4] **A61F 13/16;** B32B 5/16; B32B 5/26; B32B 5/30

[52] **U.S. Cl.** **428/213;** 19/148; 19/302; 428/74; 428/76; 428/283; 428/286; 428/287; 428/298; 428/303; 428/311.1; 428/311.5; 428/311.7; 428/311.9; 428/319.7; 428/319.9; 428/339; 428/913; 604/368; 604/370; 604/372; 604/375; 604/376; 604/378; 604/385.1

[58] **Field of Search** 428/213, 283, 286, 287, 428/339, 913; 604/368

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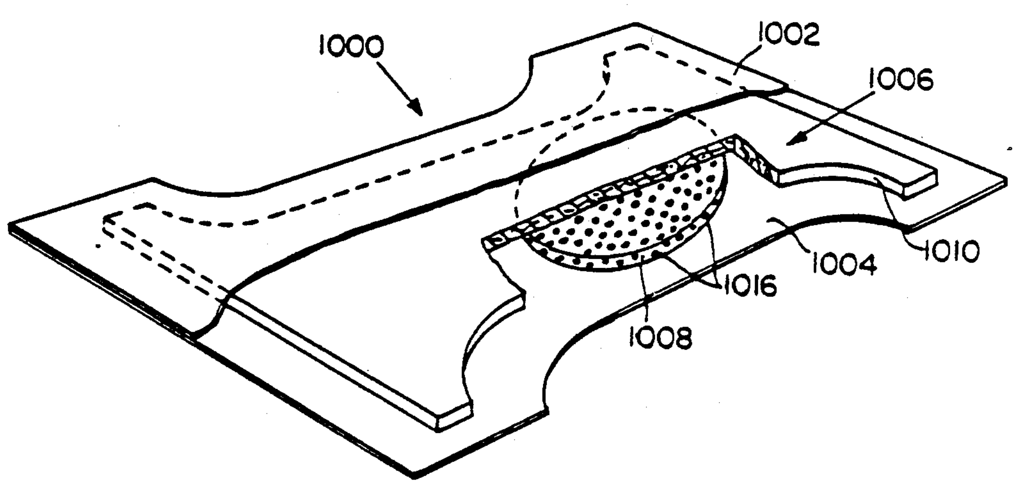
Primary Examiner—James C. Cannon
Attorney, Agent, or Firm—Steven W. Miller; John M. Pollaro; Fredrick H. Braun

[57] **ABSTRACT**

Airlaid fibrous webs having a primary layer having discrete particles of absorbent gelling material dispersed through at least a portion of the web airlaid over a dusting layer of essentially hydrophilic fiber material. The dusting layer acts to block the passage of particles injected in the stream of fibers forming the primary layer so as to minimize equipment plugging problems and the loss of particles or fibers through the foraminous forming element and to provide a more efficient absorbent core.

10 Claims, 7 Drawing Sheets



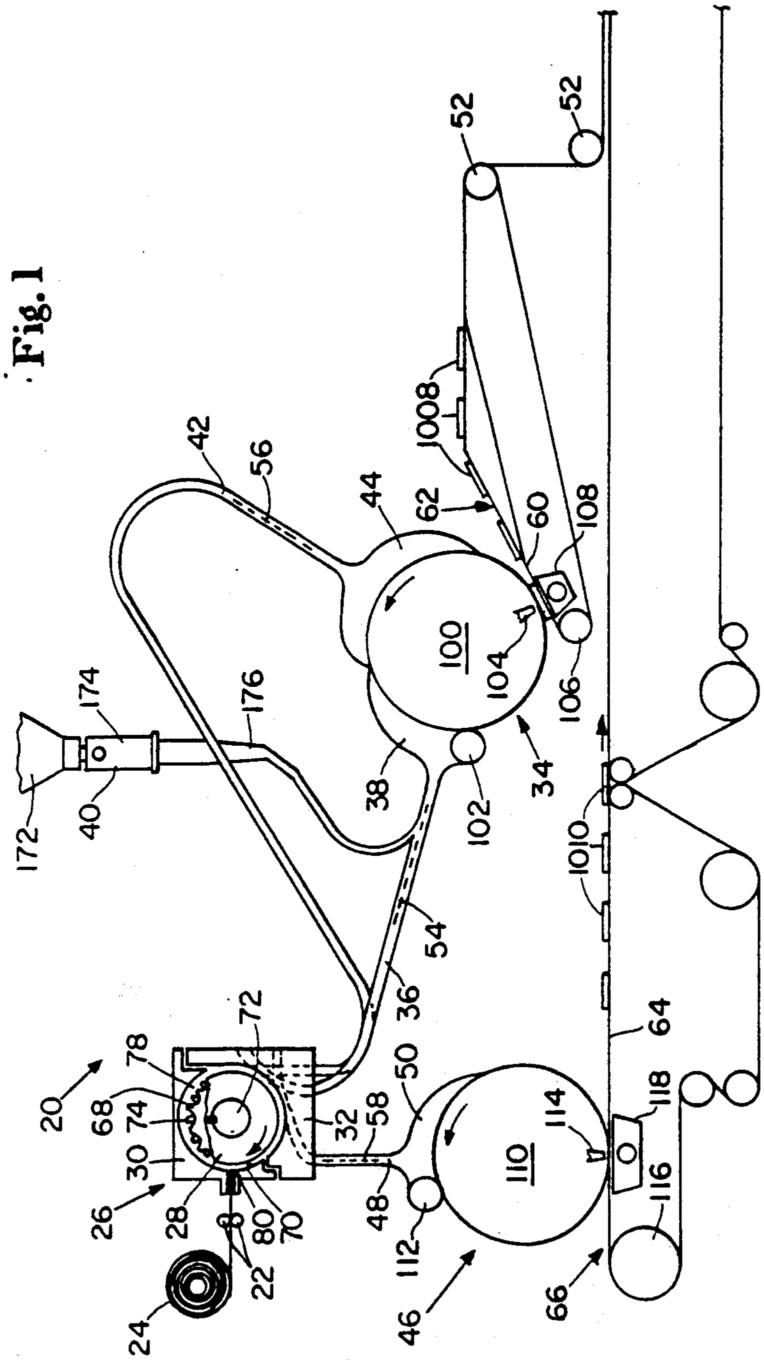


Fig. 1

Fig. 2

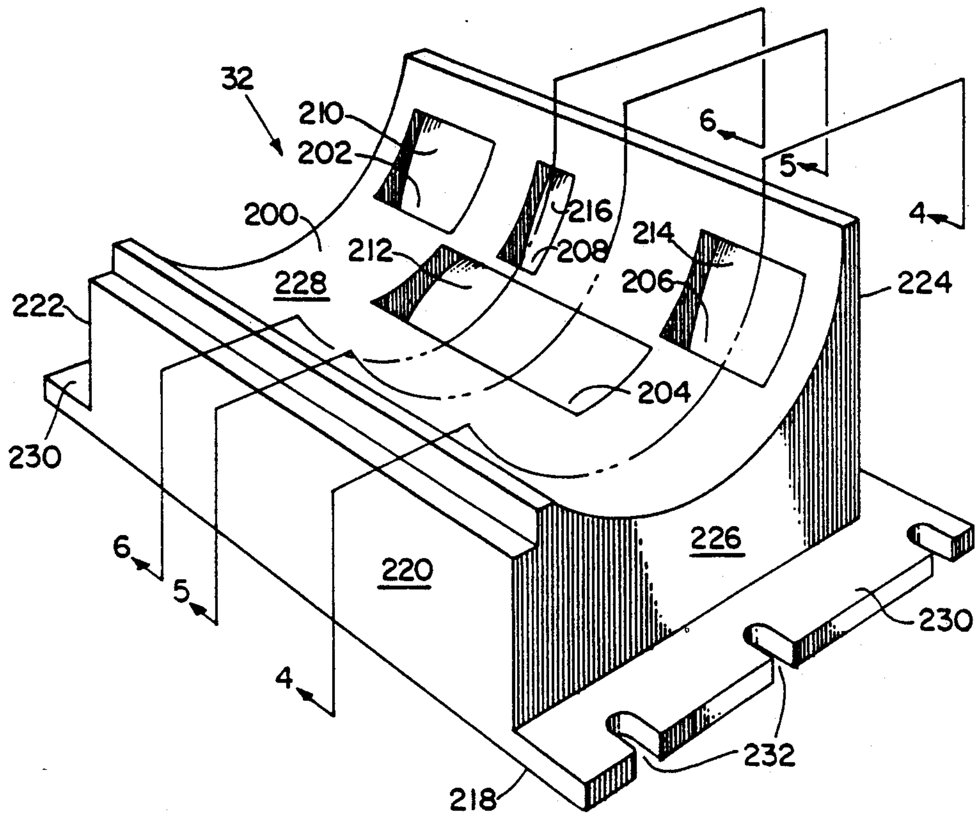

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Fig. 3

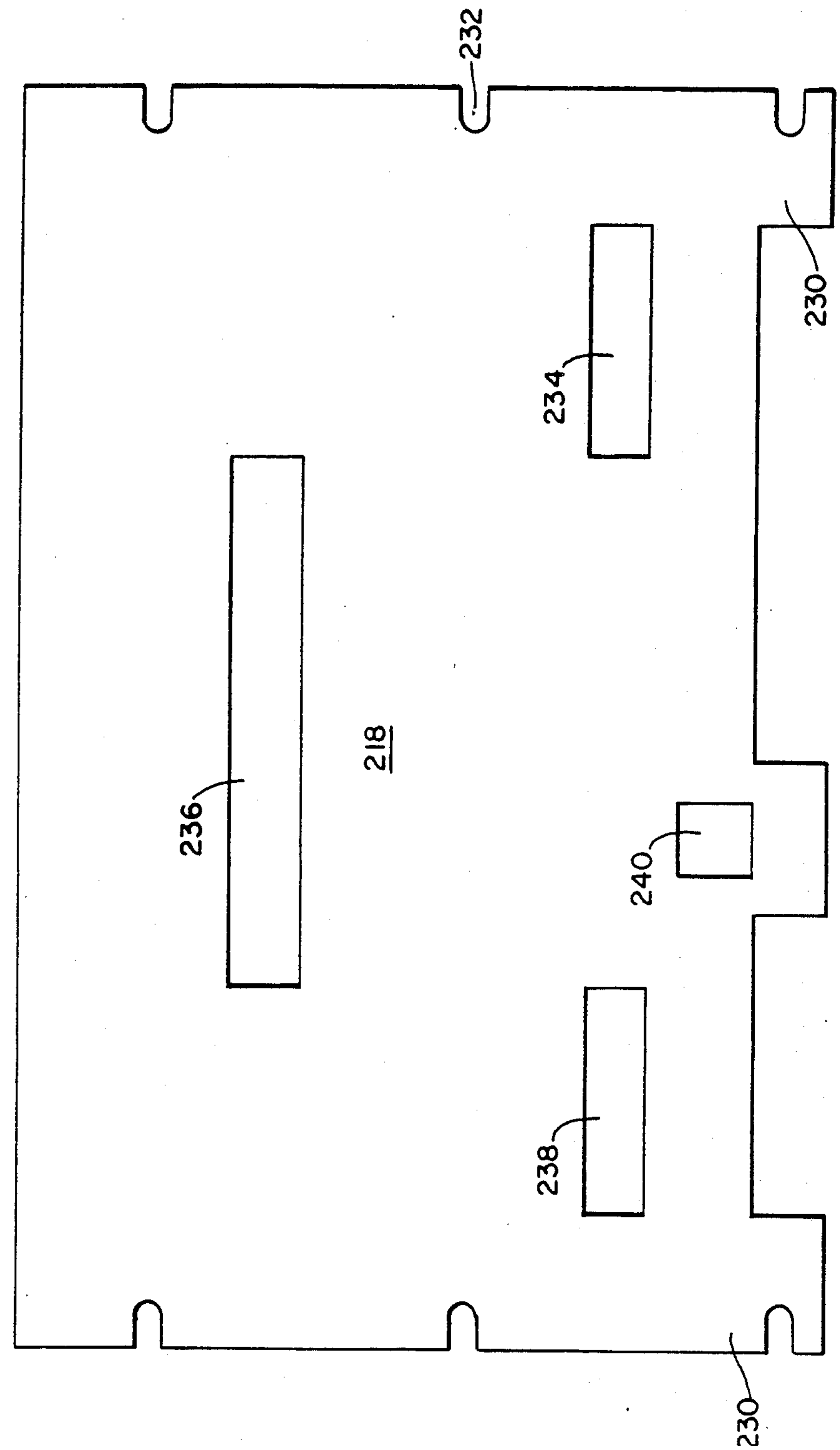

Fig. 4

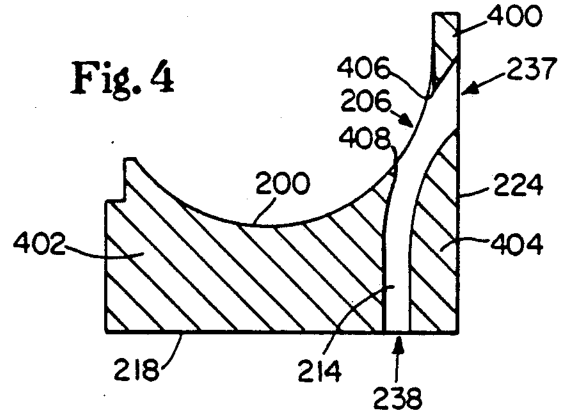

Fig. 5

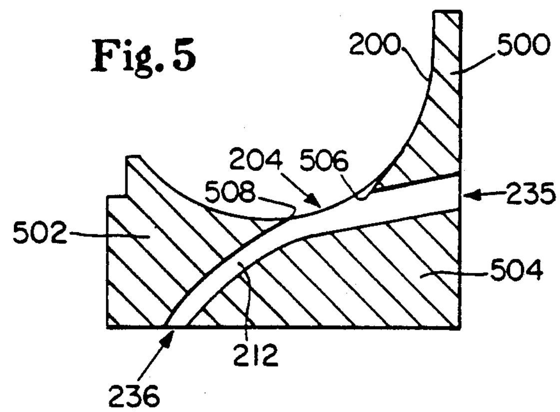

Fig. 6

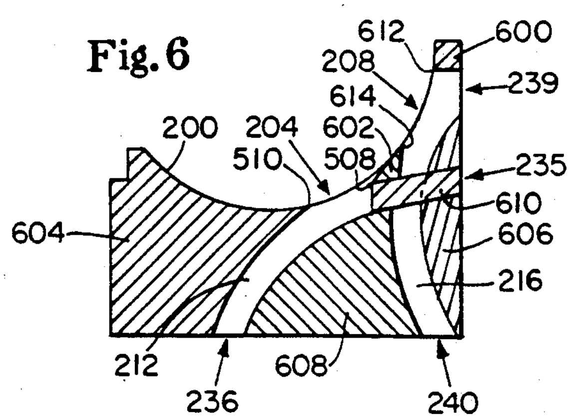

Fig. 7

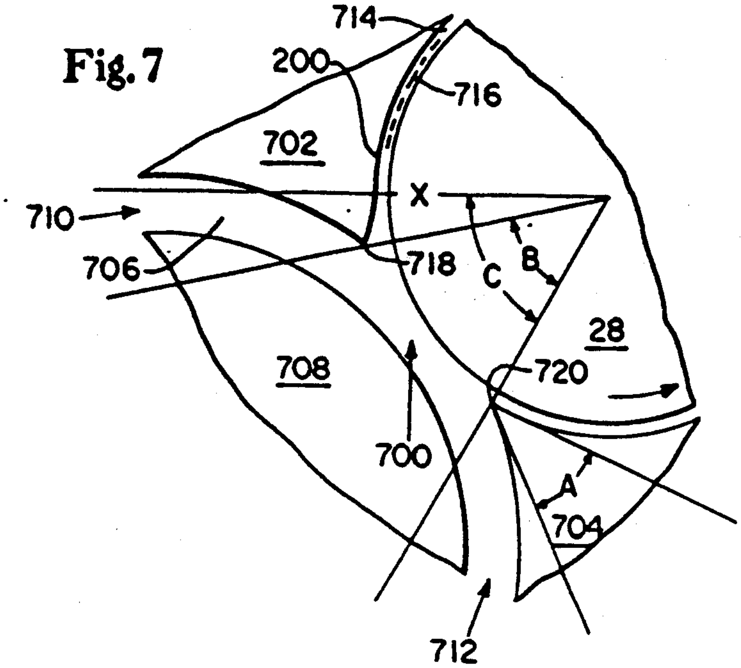

Fig. 8

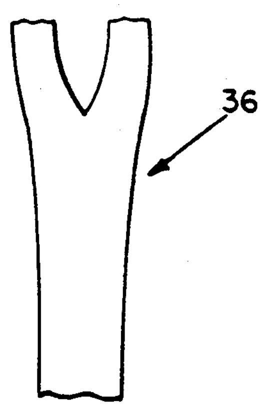

Fig. 9

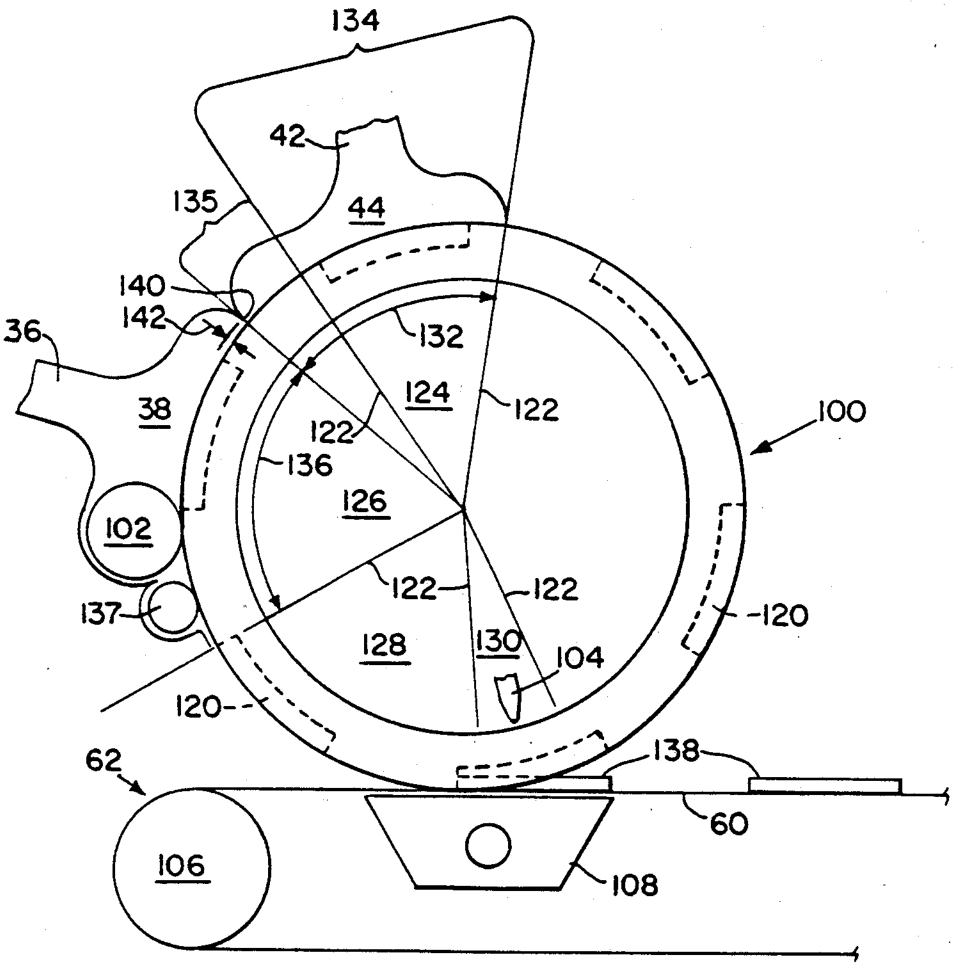
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Fig. 10

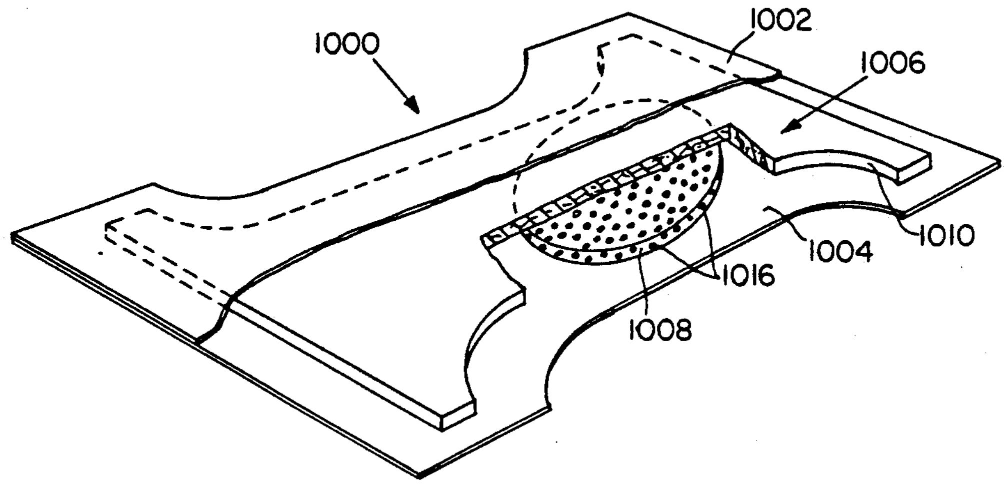
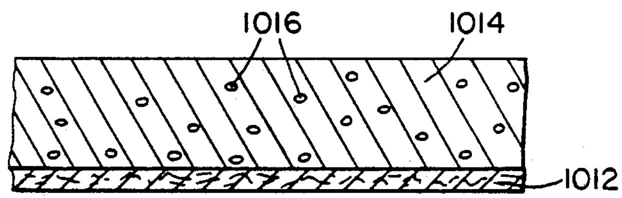


Fig. 11



ABSORBENT CORE HAVING A DUSTING LAYER

This application is a continuation of application Ser. No. 06/868,217 filed on May 28, 1986, and now abandoned.

FIELD OF THE INVENTION

This invention relates to airlaid fibrous webs having discrete particles dispersed through at least a portion of the web. More particularly, it relates to an absorbent core for use in an absorbent article that has a dusting layer of fibers formed by depositing a layer onto the foraminous forming element of an airlaying apparatus prior to depositing a layer of fibers mixed with discrete particles of a material such as an absorbent gelling material on the foraminous forming element so as to minimize the loss of such particles through the foraminous forming element and to provide an effective absorbent core.

BACKGROUND OF THE INVENTION

Absorbent gelling materials (AGM's) are polymeric materials which are capable of absorbing large quantities of fluids such as body fluids and wastes and which are further capable of retaining such absorbed fluids under moderate pressures. These absorption characteristics of absorbent gelling materials make such materials especially useful for incorporation into absorbent articles such as disposable diapers, incontinent pads and catamenial napkins. For example, Procter & Gamble; European patent application EP-A-122,042; published Oct. 17, 1984 discloses absorbent structures wherein discrete particles of absorbent gelling material (hydrogel particles) are dispersed in a web of hydrophilic fibers. Additionally, U.S. patent application Ser. No. 734,426 filed on May 15, 1985, now U.S. Pat. No. 4,673,402 issued June 16, 1987, by Paul T. Weisman, Dawn l. Houghton and Dale A. Gellert discloses an absorbent article having a dual-layer absorbent core wherein a shaped core component consists essentially of hydrophilic fiber material and an insert core component consists essentially of a substantially uniform combination of hydrophilic fiber material and discrete particles of absorbent gelling material.

However, several difficulties have been encountered in airlaying absorbent cores having a multiplicity of layers and/or layers containing a mixture of fibers and particular amounts of discrete particles of materials such as absorbent gelling materials. Airlaying apparatus and methods require the removal of the gas or air which transports the fiber/particle admixture from beneath the foraminous forming element of the airlaying apparatus. During this removal, small particles which are mixed with the fibers can generally be drawn along with the air through the voids in the foraminous forming element, resulting in a loss of expensive absorbent gelling materials through the airlaying apparatus, the resultant absorbent article also having a reduced quantity of absorbent gelling material dispersed throughout its absorbent core resulting in a loss of absorbent capacity in the articles. Additionally, relatively large particles tend to plug or block the flow of air through the foraminous forming element resulting in a loss of uniformity of basis weight across or along the fibrous web or absorbent core as well as machinery down time necessitated in order to unplug the foraminous forming element. Thus, it would be advantageous to provide an airlaid fibrous web having discrete particles of material, such as absorbent gelling materials, dispersed through at least a portion of the web without having reduced design quantities of materials in the core and with uniform basis weights across or along the material-containing layer of the web.

Accordingly, it is an object of the present invention to provide airlaid fibrous webs having discrete particles dispersed through at least a portion of the web.

It is a further object of the present invention to provide an absorbent core wherein fibers or fiber/particle admixtures are airlaid over a dusting layer to minimize loss of particles, to provide more uniform and efficient cores, and to provide more efficient and effective use of absorbent gelling materials.

SUMMARY OF THE INVENTION

It a particularly preferred embodiment, the present invention comprises airlaid fibrous webs having a primary layer of discrete particles of absorbent gelling material dispersed through at least a portion of the web that is airlaid over a dusting layer of essentially hydrophilic fibers. The dusting layer acts to block the passage of particles or fibers entrained in the primary layer so as to minimize equipment plugging problems and the loss of particles or fibers through the foraminous forming element. In addition, the dusting layer acts as a wicking layer, preferably adjacent the backsheet, to provide improved liquid acquisition and distribution by quickly acquiring liquids that migrate, such as by gravity, to the backsheet-side of the core and by transporting such liquids to the primary layer for storage of such liquids.

The present invention also relates to dual-layer cores and absorbent articles utilizing such absorbent cores having a dusting layer overlaid by a primary layer.

BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the present invention, it is believed the present invention will be better understood from the following description in conjunction with the accompanying drawings in which:

FIG. **1** is a partially cut-away side view of a preferred apparatus of the present invention;

FIG. **2** is a perspective view of the splitter chute apparatus of the present invention;

FIG. **3** is a bottom view of the splitter chute apparatus of the present invention;

FIG. **4** is a cross-sectional view taken along section line **4**—**4** of FIG. **2**;

FIG. **5** is a cross-sectional view taken along section line **5**—**5** of FIG. **2**;

FIG. **6** is a cross-sectional view taken along section line **6**—**6** of FIG. **2**;

FIG. **7** is an enlarged cross-sectional illustration of a transition zone of a splitter chute apparatus;

FIG. **8** is a schematic illustration of the first deposition chute of the present invention;

FIG. **9** is an enlarged cross-sectional view of the first airlaying means of the present invention.

FIG. **10** is a cut-away view of a preferred disposable absorbent article such as a diaper having a dual-layer absorbent core formed by the apparatus and methods of the present invention.

FIG. **11** is an enlarged cross-sectional view of the insert core component of the absorbent core of the diaper shown in FIG. **10**.

DETAILED DESCRIPTION OF THE INVENTION

While the present invention will be described in detail in the context of providing airlaid fibrous webs for use as absorbent cores in absorbent articles such as disposable diapers, the present invention is in no way limited to such an application. The present invention may be employed with equal facility to provide airlaid fibrous webs for later incorporation into a number of articles, including incontinent briefs, sanitary napkins, bandages and the like.

FIG. **10** shows a particularly preferred embodiment of a disposable diaper having an absorbent core of the present invention. The disposable diaper **1000** comprises a topsheet **1002**, a liquid impervious backsheet **1004**, and an absorbent core **1006** disposed between the topsheet **1002** and the backsheet **1004**. A preferred construction of such a disposable diaper is described in U.S. Pat. No. 3,860,003, issued Jan. 14, 1975 to Kenneth B. Buell, which patent is herein incorporated by reference.

The absorbent core **1006** preferably comprises two or more distinct core components. The absorbent core comprises an insert core component **1008** (first web component) and a shaped core component **1010** (second web component). This preferred absorbent core is described in more detail in U.S. patent application Ser. No. 734,426, filed May 15, 1985, now U.S. Pat. No. 4,673,402 entitled "Absorbent Articles with Dual-Layered Cores" issued June 16, 1987 to Paul T. Weisman, Dawn I. Houghton, and Dale A. Gellert, which is herein incorporated by reference.

The shaped core component **1010** serves to quickly collect and temporarily hold and distribute discharge body fluid. Thus, the wicking properties of the materials or fibers in the shaped core component **1010** are of primary importance. Therefore, the shaped core component **1010** consists essentially of an hourglass shaped web of hydrophyllic fiber material. While many types of fibers are suitable for use in the shaped core component **1010**, preferred types of fibers are cellulose fibers, in particular, wood pulp fibers. While the shaped core component **1010** is preferably free of particles of an absorbent gelling material, the shaped core component **1010** may alternatively contain small amounts of particles of an absorbent gelling material so as to enhance its fluid acquisition properties. Other materials in combination with the fibers may also be incorporated into the core component such as synthetic fibers.

The insert core component **1008** absorbs discharge body fluids from the shaped core component **1010** and retains such fluids. As shown in FIGS. **10** and **11**, the insert core component **1008** consists essentially of a thin dusting layer **1012** of hydrophyllic fiber material overlayed by a primary layer **1014** of a uniform combination of hydrophyllic fiber material and particular amounts of discrete particles **1016** of substantially water-insoluble, fluid absorbing, absorbent gelling materials. The hydrophyllic fibers in the insert core component **1008** are preferably of the same type as those herein described for use in the shaped core component **1010**. There are several suitable absorbent gelling materials which can be used in the insert core component, such as silica gels or organic compounds such as crosslinked polymers. Particularly preferred absorbent gelling materials are hydrolyzed acrylonitrile grafted starch, acrylic acid grafted starch, polyacrylates and isobutylene maleic anhydride copolymers, or mixtures thereof.

While the dusting layer **1012** of the absorbent core **1006** is preferably a relatively thin layer of hydrophillic fiber materials, it should be understood that the term "dusting layer", used herein to denote a certain layer of the fibrous web or as a prefix to identify certain elements which form or are used to form the dusting layer, should not be limited to such a thin layer, but includes embodiments wherein such a layer may be any thickness. For example, the dusting layer is preferably about 1.0 inch to about 1.5 inch (about 25 mm to about 38 mm) thick with about 1.25 inches (about 31.75 mm) being especially preferred, although thicker or thinner layers are contemplated.

FIG. **1** discloses a particularly preferred embodiment of the apparatus for forming airlaid fibrous webs having a multiplicity of components such as the absorbent core **1006** of the disposable diaper **1000** that is shown in FIGS. **10** and **11**. In the embodiment illustrated in FIG. **1**, the apparatus **20** is shown to comprise a pair of counter-rotating metering infeed rolls **22** for directing a roll **24** of drylap material into engagement with a disintegrator **26**, the disintegrator **26** having a rotary disintegrating element **28** partially enclosed by a housing **30**; a splitting means or apparatus such as a splitter chute **32** for providing a multiplicity of streams of air-entrained fibers; a first airlaying means such as a drum-type airlaying apparatus **34** for forming a first web component; a first deposition means such as a first deposition chute **36** and hood **38** for directing a first stream of air-entrained fibers to the first airlaying means and for depositing the fibers on the first airlaying means; an absorbent gelling material injection apparatus **40** or means for mixing discrete particles of an absorbent gelling material with the stream of air-entrained fibers that is directed through the first deposition chute **36**; a dusting layer deposition means such as a dusting layer deposition chute **42** and hood **44** for directing a dusting layer stream of air-entrained fibers to the first airlaying means and depositing the fibers on the first airlaying means; a second airlaying means such as a second drum-type airlaying apparatus **46** for forming a second web component; a second deposition means such as a second deposition chute **48** and hood **50** for directing a second stream of air-entrained fibers to the second airlaying means and for depositing the fibers onto the second airlaying means; and a uniting means such as a uniting roll apparatus **52** for uniting the first and second web components. In order to simplify the disclosure, several elements or means which can readily be supplied by those skilled in the art have been omitted from the drawings. Such elements include structural members, bearings, power transmission units, controlling units and the like. Additionally, a first stream **54** of air-entrained fibers is shown in FIG. **1** to be moving through the first deposition chute **36**; a dusting layer stream **56** of air-entrained fibers is shown to be moving **32** through the dusting layer deposition chute **42**; a second stream **58** of air-entrained fibers is shown to be moving through the second deposition chute **48**; an endless stream of insert core components **1008** (first web components) is shown moving on the belt **60** of a first take-away conveyor **62**; and an endless stream of shaped core components **1010** (second web components) is shown moving on the belt **64** of a second take-away conveyor **66**.

A preferred embodiment of a disintegrator **26** is shown in FIG. **1** to comprise a rotary disintegrating element **28** partially enclosed in a housing **30**. A similar-

type disintegrator is shown in U.S. Pat. No. 3,863,296, issued on Feb. 4, 1975 to Kenneth B. Buell, which patent is herein incorporated by reference. However, as used herein, the term "disintegrator" s not intended to limit the present invention to apparatus of the type illustrated in the above patent, but includes apparatus such as hammermills, fiberizers, picker rolls, lickerin rolls or any other apparatus which separates a roll or mat of fibrous material into its individual fibers.

As used herein, a fibrous or drylap material or sheet describes any type of fibrous sheet material capable of disintegration into individual fibers. For example, the fibrous material can include fibers of rayon, polyester, cotton or the like, with cellulosic fibers being especially preferred.

The disintegrator **26** preferably comprises a rotary disintegrating element **28** comprising a plurality of rotors **68** and a housing **30** having a generally cylindrical bore **70**. A shaft **72** is journaled in the closed ends of the housing **30** such that one end of the shaft **72** extends outside the housing **30** to permit coupling the shaft in a conventional manner to a motive power source such as an electric motor (not shown). The motor continuously drives the shaft **72** in the direction as shown. The rotors **68** are keyed to the shaft **72** in juxtaposed relation, each being provided with a plurality of teeth **74** extending outwardly such that their tips are adapted to serve as impacting elements. As used herein, "rotor" refers to thin rotored discs. With the above arrangement, successive teeth **74** impact the end of the infeeding sheet **24** as the rotors are turned. The rotors **68**, when keyed into place and molded together, form an axial rotary cylindrical disintegrating element **28** rotatable about its cylindrical axis. This configuration is preferred since it permits the favorable internal distribution of stresses set up during operation of the disintegrator **26**.

The housing **30** partially encloses the disintegrating element **28** and defines a flow channel **78** for a column of fibers between the disintegrating element and the housing. The flow channel **78** is sized to give from about one thirty-second to about one-fourth inch (about 0.79 mm to about 6.35 mm) clearance between the blade tips of the disintegrating element **28** and the housing **30** so as to direct the column of fibers from the inner end of the housing toward the splitter chute **32**. The housing **30** has a cylindrical bore **70** to partially enclose the disintegrating element **28** and an inlet portion **80** which is slotted to provide an inlet opening having an inner end. (While the housing **30** may alternatively be comprised of additional elements, such are not preferred in the present invention). The inlet opening **80** is disposed so as to receive the fibrous sheet **24** and guide it to the inner end, which defines a sheet support element, whereat an edge of the fibrous sheet **24** is disintegrated.

With the above arrangement, successive teeth **74** impact the end of the infeeding drylap sheet **24** as the rotors **68** are turned to separate the fibers of the fibrous sheet **24** into individual fibers. After separation of the fibers of the fibrous sheet into the individual fibers, a column of fibers is formed across the axial width of the housing **30**. As used herein, "a column of fibers" denotes a pattern or system of fibers disposed across the axial width of the housing. The rotation of the disintegrating element **28** imparts an inherent velocity to the fibers across the axial width of the housing **30**, whereupon a continuous column of fibers is directed around the flow channel **78** toward the splitter chute **32**.

As shown in FIG. **1**, the splitter chute **32** is preferably joined to the housing **30** of the disintegrator **26**. The term "joined" includes embodiments wherein the splitter chute **32** is a separate element directly or indirectly connected to or within the housing **30** (i.e. integral) or embodiments wherein the splitter chute **32** is the same element as the housing **30** so that the splitter chute **32** is a continuous and undivided element of the housing **30** (i.e. unitary). While the splitter chute **32** may be an independent apparatus from the disintegrator **26**, or the splitter chute **32** may be unitary with the housing **30** of the disintegrator **26**, such embodiments are not preferred. The splitter chute **32** is preferably an integral member that is joined into the housing **30** of the disintegrator **26**.

FIG. **2** shows a particularly preferred embodiment of an apparatus (splitting means or splitter chute **32**) for forming a multiplicity of streams of air-entrained fibers by splitting a column of fibers into a multiplicity of fiber streams and independently entraining each of the fiber streams in air. As shown in FIG. **2**, the apparatus comprises a splitting member **200** having a number of ports disposed in and along its surface. As shown, the ports are designated a first port **202**, a second port **204**, a third port **206**, and a dusting layer port **208**. The apparatus also comprises multiple independent conduit means, such as conduit ducts, for directing high velocity columns of air past the ports disposed along the stripping member **200**. The conduit ducts are designated in FIG. **2** according to which port with which the conduit duct is in communication, so as to define a first conduit duct **210**, a second conduit duct **212**, a third conduit duct **214** and a dusting layer conduit duct **216**.

The splitter chute **32** shown in FIG. **2** is a preferred embodiment of the apparatus of the present invention. The splitter chute is shown in FIG. **2** to additionally comprise a base **218**, four side walls **220, 222, 224** and **226**, respectively, and a top wall **228** which defines the splitting member **200**. The base **218** preferably extends beyond the lateral side walls **222** and **226** to define flanges **230** having bores **232** so that the splitter chute **32** may be bolted or otherwise secured in any conventional manner to the housing **30** of the disintegrator **26**. FIG. **3** shows a preferred embodiment of the base **218**, the base **218** being shown to accommodate the discharge outlets of each of the conduit ducts. As shown in FIG. **3**, the discharge outlets are designated a first discharge outlet **234**, a second discharge outlet **236**, a third discharge outlet **238** and a dusting layer discharge outlet **240**.

The splitting member **200** provides a means for splitting the column of fibers into multiple fiber streams. The splitting member **200** directs the column of fibers to the ports where portions of the column of fibers are split-off into individual fiber streams. The term "splitting member" is used herein to describe a number of different structures having varying configurations and shapes such as ducts, pipes, sheets or combinations of sheets of material, a number of plates in combination, or a number of different elements in combination. The splitting member **200** is shown in FIG. **2** as a curvilinear surface defined by the top wall **228** of the splitter chute **32**. However, alternative preferred slitting members include a duct having ports disposed therein or, for example, if the splitter chute **32** is unitary with the housing **30** of the disintegrator **26**, the splitting member **200** may comprise a combination of a portion of the disintegrating element **28**, the housing **30**, and the surface of

the top wall 228 of the splitter chute 32, together defining a flow channel 78 through which the column of fibers may be directed.

While the splitting member 200 may have a number of configurations, the surface in which the ports are located or disposed preferably has a curvilinear profile. A curvilinear profile provides angular displacement and velocity components to the fibers to assist in separating and in drawing off the fibers into the individual conduit ducts without the presence of fiber catching mechanical edges or walls such that fiber clumping is minimized. While flat or rectilinear splitting members are contemplated by the present invention, they do not provide this angular displacement advantage as will be described later. In addition, when the splitter chute 32 is joined to the housing 30, a curvilinear splitting member accommodates the shape of the disintegrating element 28. While the curvilinear profile of the splitting member is preferably circular in nature, a number of different curvilinear profiles would be equally preferred such as hyperbolic, parabolic or ellipsoid profiles.

The splitting member 200 may be positioned anywhere relative to where the column of fibers are discharged by the disintegrating element 28. For example, the splitting member 200 of the splitter chute 32 may be positioned relatively for downstream from the disintegrator 26. However, this configuration is not preferred because the column of fibers tends to lose its momentum and is subject to width biasing into fiber wads the farther from the disintegrating element 28 the splitting member 200 is positioned. Thus it has been found that in order to have as clean and accurate a split as possible (a split which provides consistent basis weight fiber streams and minimizes fiber clumping), the splitting member 200 should be positioned as closely as possible to the disintegrating element 28, preferably adjacent to it so that the column of fibers is drawn away from and off of the disintegrating element as it is split into the fiber streams.

As shown in FIG. 2, the splitting member 200 is provided with a number of ports. The ports put the columns of air that are directed through the conduit ducts in communication with the portion of the column of fibers that is directed along the splitting member 200 so that portions of the fiber column may be split-off and drawn into the conduit duct to form a distinct fiber stream. Thus the ports provide an opening for the intake of a stream of fibers into the conduit ducts. While the ports may take a number of shapes and configurations, a preferred configuration of each of the ports is a rectangular-shaped opening having an upstream edge and a downstream or doctor's edge. (These edges are shown and described more particularly in FIGS. 4, 5 and 6).

In order to effectively and efficiently split-off the fibers, at least two ports must be at least partially laterally spaced from each other. As used herein, the term "laterally spaced" is used to denote that a portion of a port is offset to one side of and out of alignment with at least a portion of another port such that a line that is perpendicular to the lateral dimension would not intersect both of the ports. (Lateral being defined as the dimension across the width of the splitting member.) Thus, a partially laterally spaced port denotes that a portion of the first port is disposed to one side of and out of alignment with a potion of the second port. The ports may alternatively and preferably be completely axially offset. In addition, each of the ports may be either longitudinally aligned or spaced downstream or upstream from each other. The term "longitudinally spaced" being used herein to denote that a port is disposed upstream or downstream from another. (Longitudinal being defined as the dimension along the length of the splitting member.) A preferred configuration provides that each successive port be laterally spaced and longitudinally spaced from each successive port. This configuration providing the most efficient split of the fiber column.

As shown in FIG. 2, the first port 202 preferably is disposed adjacent a lateral side wall 222 of the splitter chute 32, an outermost portion of the column of fibers thereby being split-off by the first port 202. The second port 204 is preferably longitudinally spaced downstream and laterally spaced from the first port 202 so as to split-off a second or central width of the column of fibers. The third port 206 is preferably longitudinally aligned with the first port 202 but is laterally spaced from both the first and second ports so as to strip off a third width of fibers from the column of fibers. The dusting layer port 208 which is provided to create a stream of fibers that is used to form the dusting layer, is longitudinally aligned with but laterally spaced from both the first and third ports 202 and 206, but is laterally aligned with but longitudinally spaced from a portion of the second port 204. While the ports may be longitudinally and laterally arranged in a number of different configurations, the configuration shown in FIG. 2 is especially preferred to provide a fibrous web having two core components, one of the components having discrete particles of absorbent gelling material dispersed through one of its layers.

The first and third ports 202 and 206 are preferably centered relative to the second port 204 on the outer edges of the splitting member 200 so as to accommodate variations in the width of the drylap sheet that is fed into the disintegrator 26. Because the fiber streams that are formed from the first and third ports 202 and 206 are merged in the first deposition chute 36 downstream of the splitter chute 32, if there are any major variations in the width of the drylap sheet 24, this variation will not cause a significant change in the basis weight of the web component (insert layer) formed by the first and third fiber streams because they are merged into a combined or primary fiber stream. Thus, the first and third ports 202 and 206 should have equal widths and be positioned symmetrically about the centerline of the splitter chute 32 or splitting member 200.

While the dusting layer port 208 is preferably laterally spaced and longitudinally spaced from all of the ports so that the column of fibers is more efficiently split into four fiber streams, space and size constraints require that the preferred embodiment of the splitter chute 32 have the dusting layer port 208 laterally aligned with a portion of the second port 204 and longitudinally aligned with the first and third ports 202 and 206. The dusting layer port 208 is laterally aligned with a portion of the second port 204 because the second port 204 is preferably much wider than the first and third ports 202 and 206 such that the loss of such a small stream of fibers will have a minimal effect on the ultimate basis weight of the core component formed by the second fiber stream. As shown in FIG. 2, the dusting layer port 208 is preferably laterally spaced from the centerline of the splitter chute 32 toward an edge of the second port 204 so that any effect that the removal of the dusting layer fiber stream has on the basis weight of the hourglass shaped core component is centered along

the ears of the shaped core component rather than in the primary absorbent area of the shaped core component.

The conduit ducts provide a means through which a column of high velocity air as well as streams of air-entrained fibers are directed or conveyed. The conduit ducts may be separated elements such as pipes, channels or ducts which are secured to the splitting member **200** adjacent the ports, or an integral element formed by the positioning of plates as is shown in FIGS. **4**, **5** and **6**. The conduit ducts should be configured for flow rates of preferably greater than or equal to about 75 ACFM per inch of disintegrating element **28** width and for velocities of preferably greater than or equal to about 6,000 feet per minute, more preferably about 10,000 fpm. Thus it is preferably to make the conduit ducts about 1 inch thick and as wide as required to be in complete communication with the full width of the particular port with which the duct is in communication. While the conduit ducts may have any particular cross-sectional shape, rectilinear ducts or curvilinear ducts having a radius of curvature greater than about 6 inches are especially preferred. While rectilinear conduit chutes minimize air and fiber turbulence within the ducts, especially when such ducts are disposed tangentially to the curvilinear surface of the splitting member **200** adjacent that particular port, curvilinear ducts are especially preferred due to size and shape constraints and equipment arrangement.

The inlets of the conduit ducts provide a means to inject or draw ambient air into the conduit ducts at relatively high velocities. While the inlet ports may take on a number of different configurations, a configuration having an aerodynamic shape is believed to function to minimize air turbulence as the air is drawn into the conduit duct.

A preferred configuration of the discharge outlets along the base **218** of the splitter chute **32** is shown in FIG. **3**. The first and third discharge outlets **234** and **238** are preferably aligned across the width of the base so that the first deposition chute. **210** which merges the fiber streams downstream may conveniently be secured to both discharge outlets. The dusting layer discharge outlet **240** is slightly offset from the first and third discharge outlets **234** and **238** to more easily accommodate the dusting layer deposition chute. The second discharge outlet **236** is set apart from all of the other discharge outlets due to the configuration of the second conduit duct and to facilitate equipment arrangements of two laydown drums.

The percentage of the total airfelt weight per absorbent core that will form each of the specific core components will vary according to the size of the absorbent article that is being manufactured. Thus a large diaper may require a greater percentage of the total airfelt weight in the shaped core component than a medium diaper. Because the axial width of the ports determine the percentage of airfelt dedicated to each core component, it is preferably that the axial width of each port across the total axial width of the splitting member **200** be able to be changed according to the core component airfelt weights. Accordingly, the splitter chute **32** is preferably manufactured from a series of plates that are bolted or otherwise secured together in any conventional manner to form varying size chambers so that the width of each port, and correspondingly the width of each conduit duct, may be varied to accommodate the particular basis weight required in the final core component.

FIG. **4** shows a cross-sectional view of a preferred embodiment of the splitter chute **32** taken along sectional line **4—4** of FIG. **2**. The cross-sectional view illustrates the configuration of the splitting member **200**, the third port **206**, and the third conduit duct **214** having an inlet **237** and a discharge outlet **238** in the third chamber or splitting region of the splitter chute **32**. (While the present invention will be described with reference to the third chamber or splitting region, it should be understood that the description is equally applicable to the first chamber or splitting region.) The above elements are preferably formed and defined by three plates comprising a top plate **400**, a downstream plate **402**, and a base plate **404**.

The top plate **400** defines a portion of the top wall **228** or splitting member **200** of the present invention as well as a top wall of the third conduit duct **214**, a portion of the inlet **237**, and the upstream edge **406** of the third port **206**. The portion of the top plate **400** that defines the upstream edge **406** of the third port **206** is shown to be tapered away from the circular profile of the splitting member **200**. This configuration is preferred so that the portion of the column of fibers directed in the third chamber will begin to depart from the disintegrating element **28** due to the lack of constraint provided by the tapered upstream edge **406** as well as the fact that each fiber has an angular velocity component directed tangentially to its angular path which tends to direct or release the fibers away from the disintegrating element **28**.

The downstream plate **402** defines the portion of the splitting member **200** that is downstream of the third port **206**, a portion of a wall of the third conduit duct **214**, and a portion of the base **218** of the splitter chute **32**. Additionally, the downstream plate **402** defines the downstream edge or doctor's edge **408** of the third port **206**. In conventional disintegrating apparatus, this doctor's edge is a point where a significant amount of the fibers are removed from the teeth of the disintegrating element and directed into a conduit duct. The result of this removal at the doctor's edge causes a significant amount of fiber clumping along the doctor's edge. However, the term "doctor's edge" is used herein for descriptive purposes. Very little, if any, fibers are removed from the teeth **74** of the disintegrating element **28** by this edge. Most of the fibers are removed by the effects of the pressure differential established adjacent the port and the angular velocity and momentum of the fibers as the fibers are drawn or pulled away from the disintegrating element. Thus, there is reduced fiber clumping along this doctor's edge **408**.

The base plate **402** defines a wall of the third conduit duct **214**, as well as a portion of the base **218** and side wall **224** of the splitter chute **32**.

FIG. **5** shows a cross-sectional view of a preferred embodiment of the splitter chute taken along sectional line **5—5** of FIG. **2**. The cross-sectional view illustrates the configuration of the splitting member **200**, the second port **204**, and the second conduit duct **212** having an inlet **235** and a discharge outlet **236** in the second chamber or splitting region of the splitter chute **32**. (This portion of the second chamber is where no dusting layer fiber stream is formed.) The above elements are preferably formed and defined by three plates comprising a top plate **500**, a downstream plate **502** and a base plate **504**. These plates are arranged in a similar manner and define similar portions of the splitter chute as the plates shown in FIG. **4** except that the second

port **204** and the second conduit ducts **212** are arranged downstream along the splitting member **200** from where the first and third ports **202** and **206** are disposed. The upstream edge **506** and the doctor's edge **508** of the second port are also shown in FIG. **5**.

FIG. **6** shows a cross-sectional view of a preferred embodiment of the splitter chute **32** taken along sectional line **6—6** of FIG. **2**. The cross-sectional view illustrates the configuration of the splitting member **200**, the dusting layer port **208**, the second port **204**, the dusting layer conduit duct **216** having an inlet **239** and a discharge outlet **240** and the second conduit duct **212** having an inlet **235** and a discharge outlet **236**, in the dusting layer chamber or splitting region of the splitter chute. While the dusting layer chamber may be configured in a number of different ways, including the configuration shown in FIG. **4** wherein the second port and duct would not be formed in the dusting layer chamber, such embodiments are not preferred. The above elements are preferably formed and defined by six plates comprising a top plate **600**, an intermediate plate **602**, a downstream plate **604**, a side plate **606**, a base plate **608**, and a wedge plate **610**.

The splitting member **200** is formed from the top surface of the top plate **600**, the intermediate plate **602** and the downstream plate **604**. The intermediate plate **602** acts as a separator to define the ports. The dusting layer port **208** is defined by the top plate **600** and the intermediate plate **602**; the top plate **600** defining the upstream edge **612** of the dusting layer port **208** and the intermediate plate **602** defining the doctor's edge **614** of the dusting layer port **208**. The second port **204** is defined by the intermediate plate **602** and the downstream plate **604**; the intermediate plate **604** defining the upstream edge **508**, and the downstream plate **604** defining the doctor's edge **510** of the second port **204**. The dusting layer conduit duct **216** is formed by the top plate **600**, the side plate **606**, the intermediate plate **602**, and the base plate **608**. The second conduit duct **212** is defined by the intermediate plate **602**, the downstream plate **604** and the base plate **608**. It should be noted that the second conduit duct **212** is blocked by the wedge plate **610**. The wedge plate **610** is a plate having tapered ends and a square hole cut vertically through the plate so as to block the flow of air through the portion of the second conduit duct **212** which is in communication with the dusting layer conduit duct **216** while permitting the flow of air through the dusting layer conduit duct **216**.

A particularly exemplary splitter chute **32** is configured of twenty-seven sets of plates across its width, each of the plates having a width of about five-eighths inch (about 15.8 mm). Thus, the cumulative width of the splitter chute **32** is about seventeen inches (about 432 mm). The first and third chambers are configured of from about four to about eight plates each such that the first and third ports **202** and **206** each have a width of about 2.5 to about 5.0 inches (about 63.5 to about 127 mm). The second chamber is configured of from about thirteen to about twenty plates such that the width of the second port **204** is about 8.12 to about 12.5 inches (about 206 to about 317.5 mm). Of these thirteen to twenty plates, about two to four plates are configured to provide the dusting layer chamber such that the dusting layer port **208** has a width of about 1.25 to about 2.5 inches (about 31.75 to about 63.5 mm.). The dusting layer chamber being laterally spaced from the first

chamber by at least two plates or about 1.25 inches (about 31.75 mm).

The splitter chute **32** is preferably operated such that each column of air that is drawn through the conduit ducts has a velocity of about six-thousand to about fifteen-thousand feet per minute (about 1.83 to about 4.57 km per minute), preferably about ten-thousand feet per minute (3.05 km per minute) and a flow rate of from about 40 to about 100 ACFM per inch, preferably about 75 ACFM per inch.

FIG. **7** shows an expanded cross-sectional view of a preferred embodiment of the splitter chute **32** adjacent any of the ports of the present invention. The disintegrating element **28** is shown to be rotating in a computer-clockwise direction. The splitting member **200** having a port **700** is shown to be a curvilinear surface formed by a top plate **702** and a downstream plate **704**. The conduit duct **706** is formed from the surfaces of the top plate **702**, the downstream plate **704** and the base plate **708**, the inlet of the conduit duct **706** being designated **710** and the discharge outlet being designated **712**. Also as shown in FIG. **7**, the disintegrating element **28**, the splitting member **200**, and the housing (not shown) define a narrow flow channel **714** through which the column of fibers **716** is directed. The upstream edge **718** of the port **700** (the edge of the top plate **702** adjacent the port **700**) is shown in FIG. **7** to be tapered away from the disintegrating element **28**. (As previously discussed, this configuration is preferred so that the fibers may begin to release from the disintegrating element.) The doctor's edge **720** or downstream edge of the port **700** (the edge of the downstream plate **704** adjacent the port **700**) is shown to have an included angle "A" as defined by the tangents to the surfaces of the plate. A tangent release point, designated by the "X" in FIG. **7**, is the point defined wherein the tangential component of angular velocity of the fiber is such that the fiber tends to release from its angular path away from the disintegrating element **28**. While the tangent release point may be positioned either upstream or adjacent the port **700**, it is preferable that the tangent release point be configured slightly upstream of the port **700** to provide the maximum stripping effect while minimizing clumping.

It has been found that the geometry of the members may have an important determination upon whether fiber clumping can be minimized. The angle "8" formed between the upstream edge **718** and the doctor's edge **720** defines the actual opening of the port **700**. The actual opening is preferably not greater than about 60°, more preferably about 15° to about 45° and most preferably about 30°. The angle "C" defined by the angle between the tangent release point, X, and the doctor's edge **720** defines an effective opening of the port **700**. The effective opening is preferably not greater than about 75°, more preferably about 30° to about 60°, and most preferably about 40° to about 45°. Thus the tangent release point should not be disposed upstream of the port **700** by more than about fifteen degrees (15°). It has also been found that the included angle, angle "A", is preferably about 15° to about 60°, most preferably about 45°. It should also be noted that the angle between the ports from center-to-center should preferably be not greater than about 90°, more preferably about 30° to about 60°, and most preferably about 45° to achieve a sufficient separation between the ports to minimize interaction between the ports.

Referring to FIG. 7, the operation of the apparatus of this invention will be described. The column of fibers **716** is directed around the flow channel **714** along the splitting member **200** of the splitter chute **32** by the pumping action of the disintegrating element **28**. The column of fibers **716** is directed along the curvilinear surface of the splitting member such that angular motion and thus angular velocity and momentum is imparted to each of the fibers in the column. A high velocity column of air is simultaneously directed through the conduit duct **706** and past the port **700**. This column of air may be provided by any conventional means (not shown) such as a blower positioned to inject air through the inlet **710** of the conduit duct **706** or a vacuum means positioned downstream of the discharge outlet **712**, preferably below the foraminous forming element of the drum-type airlaying apparatus so as to draw ambient air through the inlet **710** of the conduit duct **706**.

While not wishing to be bound by theory, by maintaining a column of high velocity air (at least about 6000 feet per minute, and more preferably about 10,000 feet per minute) flowing through the conduit ducts, it is believed that a pressure differential or low pressure zone is created between the pressure in the flow channel and the pressure in the conduit duct adjacent to or below the ports. Because of the pressure differential created by the movement of the column of air and the angular velocity and mass-derived momentum of the fibers, the fibers tend to pull away from the disintegrating element and be directed along the pathway created by the tapered edge of the upstream edge of the port while they are being drawn into the first conduit duct as a result of the pressure differential. Thus the fibers need not be split-off by the mechanical action of a doctor's edge, but are split-off as a result of air and fiber momentum, thereby minimizing clumping due to the absence of mechanical edges or walls.

The stream of fibers which is drawn into the conduit duct subsequently becomes entrained in the column of air, the resultant stream of air-entrained fibers being directed downstream and out of the discharge outlet into the corresponding deposition chute. This process is repeated along each of the ports so as to create multiple, independent streams of air-entrained fibers.

The deposition chutes provide a means for directing streams of air-entrained fibers from the splitter chute **32** to one of the airlaying means and for depositing the fibers onto the airlaying means. The deposition chutes also preferably decelerate the air-entrained fiber streams and orient the fiber streams from the discharge outlets to be compatible with the width and location of the airlaying means.

The deposition chutes may comprise any members that are known in the art that are capable of performing the above functions. Preferably, the deposition chutes comprise ducts that are designed so as to decelerate the fiber streams while minimize clumping of the fibers during their reorientation from the splitter chute to the airlaying means. The deposition chute should be designed to provide a reduction in air speed with a minimum of chute contraction and expansion angles. Preferably, the chutes provide about a two-thirds reduction in air speed and more preferably reduce the air speeds by a factor of 3 so that the fibers do not impact the laydown drum at a high velocity. Thus, the walls of the deposition chutes should have various curves and tapers to provide a gradually increasing cross-sectional area to reduce the velocity of the fiber streams. The deposition chutes preferably have a rectangular cross-sectional area.

As shown in FIG. 7, the first deposition chute **36** preferably comprises a "Y-shaped" configuration so as to merge the first and third fiber streams into a primary or combined fiber stream. Preferably, the first deposition chute **36** is designed to minimize the turbulence encountered with the merging of the two fiber streams. Thus, this chute preferably uses a fifth order polynomial curve profile or other profiles having their first and second derivative equal to zero so as to blend the fiber streams into a single stream.

As shown in FIG. **1**, the apparatus **20** and more particularly the first deposition chute **36**, is preferably provided with a means for providing discrete particles of absorbent gelling material. The absorbent gelling material injection apparatus **40** or means mixes discrete particles of absorbent gelling material with the combined or primary stream of air-entrained fibers prior to the deposition of the stream onto the first airlaying means. An exemplary type of injection means is shown in U.S. Pat. No. 4,551,191 issued to Ronald W. Kock and John A. Esposito on Nov. 5, 1985, said patent being herein incorporated by reference. The injection means preferably comprises a hopper (not shown) for storing a quantity of absorbent gelling material, a feed device (not shown) for metering the release of absorbent gelling material through an inlet duct **172** into an eductor **174** which entrains the absorbent gelling material in air, and a spreading duct **176** which provides air-entrained absorbent gelling material particles to the fiber streams. The absorbent gelling material is then entrained in and mixed with the fiber streams before the admixture is deposited on the laydown drum. Any other suitable injection means as are known in the art may also be used for the invention. In addition, any of the other deposition chutes may be provided with absorbent gelling material injection means as are required.

The uniting means or apparatus provide a means for uniting the web components. "Uniting" is used herein to denote that the webs are brought together in direct or indirect relationships to form an airlaid fibrous web. While many uniting apparatus are known in the art, a preferred uniting apparatus comprises a pair of uniting rolls upon which a continuous stream of enwrapped insert core components are directed to be positioned adjacent the shaped core components **1008**.

Any other uniting means, including embodiments wherein the insert core components are blown-off of the first airlaying means directly onto the shaped core components, are also comtemplated by the present invention.

The first and second airlaying means or apparatus, for forming fibrous webs are shown in FIG. **1** to preferably comprise drum-type airlaying apparatus. While the airlaying apparatus of the present invention may alternatively comprise a number of different configurations such as a moving foraminous screen, a drum-type airlaying apparatus is especially preferred. Typical drum-type airlaying apparatus useful in the present invention are shown in U.S. Pat. No. 4,388,056, issued to F. B. Lee and O. Jobes, Jr., on June 14, 1983, and U.S. patent application Ser. No. 576,098, filed on Feb. 1, 1984 by B. R. Feist, J. E. Carstens and D. A. Peterson, both of which are herein incorporated by reference. While the present invention can be practiced using a drum-type airlaying apparatus either which forms an endless or continuous web or which forms discrete webs or arti-

cles, the following description will be related to a drum-type airlaying apparatus for making discrete fibrous webs.

The first drum-type airlaying apparatus **34** is shown in FIG. **1** to comprise a first deposition or laydown drum **100** having a foraminous forming element (not shown) disposed about the drum's periphery; a first scarfing roll **102**; a first blow-off means or nozzle **104**; a first take-away conveyor **62** disposed about mounting rolls **106**; and a first transfer vacuum box **108** positioned beneath the upper run of the take-away conveyor **62**. The second drum-type airlaying apparatus **46** preferably comprises a second deposition or laydown drum **110** having a foraminous forming element (not shown); a second scarfing roll **112**; a second blow-off means or nozzle **114**; a second take-away conveyor **66** disposed about mounting rolls **116**; and a second transfer vacuum box **118** positioned beneath the upper run of the second take-away conveyor **66**. Means not shown in FIG. **1** include means for driving the drums, differential pressure means including a vacuum plenum duct, fan and a fan drive to draw fiber-depleted air through either the foraminous forming elements and to exhaust the air out of the drum through a duct.

Thus, the apparatus **20** provides a means for converting an endless length or roll of drylap material into a succession of fibrous webs for use as absorbent cores in disposable diapers, catamenial napkins and the like. As shown in FIG. **1**, a roll of drylap material **24** is unrolled into a sheet which is advanced to the disintegrator **26**. The sheet is fed radially into the disintegrator **26** by the pair of counter-rotating metering infeed rolls **22**. An inlet opening **80** in the housing **30** of the disintegrator **26** receives the fibrous sheet and guides it to the inner end of the housing **30** where the edge of the fibrous sheet is disintegrated into a column of fibers disposed across the axial width of the housing **30**. The column of fibers is directed around the flow channel **78** by the pumping action of the disintegrating element **28** to the splitter chute **32**. The column of fibers is split into multiple fiber streams that are entrained in air by the splitter chute **32**, the air-entrained fiber streams being directed out of the splitter chute **32** into the deposition chutes.

A dusting layer fiber stream **56** is directed through the dusting layer deposition chute **42** to the first laydown drum **100** where the fibers are deposited on the foraminous forming element of the first laydown drum **100**. Preferably, a first fiber stream **54** and a third fiber stream (not shown) are merged in and directed through the first deposition chute **36** where the combined or primary fiber stream is mixed with discrete particles of absorbent gelling material that are injected into the first deposition chute **36** by the absorbent gelling material injection apparatus **40**. The resultant admixture is directed to the first laydown drum **100**, whereupon the fiber/absorbent gelling material admixture is deposited and collected on the foraminous forming element over the dusting layer, downstream of the position where the dusting layer was formed. The fiber-depleted entrainment air is drawn through the foraminous forming element by the vacuum maintained behind the foraminous forming element. The resultant first web component is then transferred to the first take-away conveyor **62** by the blow-off nozzle **104** and the transfer vacuum box **108** located under the conveyor belt. The second web component is preferably formed in a similar manner as the first web component by directing a second fiber stream **58** through the second deposition chute **48**, by depositing and collecting the second fiber stream **8** on the foraminous forming element of the second laydown drum **100**; and by transferring the resultant second web component onto a second take-away conveyor **66**.

Before uniting the web components, the web components may be finished by different operations such as calendaring, enwrapping or reinforcing the webs as are known in the art. As shown in FIG. **1**, the first web component is enwrapped in tissue by means of a folding board, whereupon the continuous stream of enwrapped first core components is directed to the uniting rolls. The web components are then united by directing the continuous stream of enwrapped first web components over the uniting means or rolls **52** whereupon they are brought into contact with the second web components. Other converting operations as desired may then be effected upon the resultant fibrous web downstream from the uniting means or rolls **52** to produce a finished disposable absorbent article such as a disposable diaper.

FIG. **9** shows an enlarged sectional view of a preferred embodiment of the first drum-type airlaying apparatus **34** of the present invention. As shown in FIG. **9**, the apparatus for forming fibrous webs having discrete particles dispersed therein or having a multiplicity of layers preferably comprises a laydown drum **100** having a foraminous forming element consisting of a plurality of formation cavities **120** circumferentially spaced about the periphery of the drum **100**. The number of cavities **120** can be varied depending upon the size of the drum **100** or the size of the webs to be formed. In the embodiment shown, the drum **100** contains six cavities. A plurality of ribs **122** are mounted within the interior of the drum **100** to define a dusting layer vacuum chamber **124**, a first or primary vacuum chamber **126**, a hold-down vacuum chamber **128**, and a blow-off chamber **130** having a blow-off means or nozzle **104**. Each of the vacuum chambers is connected to a suitable source of vacuum (not shown) by vacuum ducts (not shown). The apparatus also preferably comprises a dusting layer deposition means such as a dusting layer deposition chute **42** and hood **44** for directing a dusting layer stream of air-entrained fibers to a dusting layer sector **132** of the laydown drum **100**. The dusting layer hood **38** has a first sector **134** that circumferentially spans the entire dusting layer vacuum chamber **124** and a second sector **135** that circumferentially spans a portion of the first vacuum chamber **126**. A first or primary deposition means such as a first deposition chute **36** and hood **38** for directing a first stream of air-entrained fibers to a first sector **136** of the laydown drum **100** is also shown in FIG. **9**, the first hood **38** having sufficient circumferential span to enclose the remaining portion of the first vacuum chamber **126**. The apparatus further comprises a scarfing roll **102**; a sealing roll **137**; and a take-away conveyor **62** having an endless stream of discrete fibrous webs **138** or insert core components moving on the conveyor **62**.

A critical feature of this invention is that the first vacuum chamber **126** is disposed not only subjacent the entire first hood **38** but also under the downstream or second section **136** of the dusting layer hood **44** so that approximately equal pressures are established adjacent the intersection point **140** of the hoods. Since each of the hoods preferably has a circumferential span of one complete cavity **120** (measured from the edge of a first cavity to the same edge of a second cavity) or approximately 60 degrees for a six cavity drum, the first vacuum chamber **126** must have a circumferential span of

greater than one chamber or about 75 degrees for the embodiment shown in FIG. 9. Although the circumferential span of that portion of the first vacuum chamber **126** under the dusting layer hood **44** (i.e. the circumferential span of the second sector **136** of the dusting layer hood **44**) has not been found to be particularly critical, there should be sufficient circumferential span as to allow a minimal transition zone between the dusting layer hood **44** and the first hood **38**. This minimal circumferential span decreases as the number of cavities **120** increases and increases as the number of cavities **100** decreases.

Another critical feature is that a small gap **142** must exist between the outer surface of the laydown drum **100** and the point of intersection **140** of the hoods to allow for equalization of pressure in the portions of each hood adjacent the intersection point. If no gap existed, then there could be differential pressures in each hood so that as the drum brought the edge of the dusting layer into the first hood **38**, this pressure differential could cause the dusting layer to lift off of the screen or shear. If the gap is too large, the two deposition chutes essentially merge into one and the independent dusting layer concept is not achieved. Thus a gap **142** of not more than about one-half inch is desirable with a one-eighth inch gap being preferable so that the pressure may equalize in each portion of each hood that is adjacent to the intersection point **140**.

Another important design criteria is that each of the hoods should have a relatively wide circular taper near the intersection point **140** so that the fibers that are directed toward the laydown drum in this area do not impinge on the dusting layer at an acute angle. When fibers impinge upon the dusting layer at an acute angle, the fibers have a component of velocity which is parallel to the surface of the drum, thus the fibers tend to cause the fibers constituting the dusting layer to lift or shear. The critical shear velocity has been determined to be about 4000 feet per minute; the chute geometry being designed with this as a limiting factor. Thus it is desirable that the fibers impinge upon the fibers of the dusting layer at an angle as close to perpendicular as possible because the shear component would not exist. Thus, each of the hoods should have a relatively wide circular taper so that the fibers do not impinge upon the dusting layer at an acute angle or exceed the critical shear velocity. As shown in FIG. **9**, each of the hoods has about a three inch radius of curviture adjacent the intersection point.

The operation of the apparatus is as follows. The dusting layer stream of fibers is directed toward a circumferential span or dusting layer section **132** of the periphery of the laydown drum **100** through the dusting layer deposition chute **42** and the dusting layer hood **44**. The circumferential span preferably being equal to the span of one cavity **120** or about 60° degrees if six cavities **120** are used. The fibers are deposited onto the foraminous forming element of one of the cavities **120** on the drum **100** while the entrainment air is being drawn through the foraminous forming element by the vacuum maintained in the dusting layer vacuum chamber **124** as well as by the vacuum maintained in the primary or first vacuum chamber **126**. Thus the dusting layer is formed by the collected fibers on the foraminous forming element.

As the drum rotates, the dusting layer passes from the influence of the dusting hood **44** to the influence of the first hood **38** where a first stream of air-entrained fibers are being directed generally radially toward the periphery of the drum. However, it should be noted that the dusting layer has already been transferred to the influence of the first vacuum chamber **126** prior to passing between the hoods such that the pressure differential and velocity of the first stream do not have a tendency to shear the dusting layer apart. The fibers of the first fiber stream are thus deposited over the dusting layer while the entrainment air is drawn through the foraminous forming element by the vacuum maintained in the primary or first vacuum chamber **126**. The first or primary layer is formed by the collected fiber/AGM admixture over the dusting layer. Since the dusting layer is substantially left intact, discrete particles of absorbent gelling material do not tend to be drawn through the foraminous forming element nor plug it due to the block effect of having a layer of fibers already covering the void spaces in the foraminous forming element.

The resultant fibrous web then passes under the scarfing roll **102** where the web is leveled. The fibrous web **138** or insert core component is then transferred to the take-away conveyor **62** by the joint action of the blow-off nozzle **104** and the vacuum maintained underneath the conveyor belt. The fibrous web **138** is then conveyed downstream to subsequent converting operations to produce a finished disposable absorbent articles such as a disposable diaper.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the invention. It is intended to cover, in the appended claims, all such modifications and intended uses.

What is claimed is:

1. An absorbent article comprising:

a topsheet;

a liquid impervious backsheet associated with said topsheet; and

a dual-layer absorbent core disposed between said topsheet and said backsheet, said dual-layer absorbent core comprising:

(i) a shaped core component that quickly collects and distributes discharged body liquids, and

(ii) an insert core component that absorbs and retains discharged body fluids from said shaped core component, said shaped core component being positioned between said topsheet and said insert core component, said insert core component comprising:

(a) a dusting layer consisting of hydrophilic fiber material, and

(b) a primary layer consisting of a combination of hydrophilic fiber material and particular amounts of discrete particles of absorbent gelling material airlaid over said dusting layer,

wherein said dusting layer is relatively thinner in thickness than said primary layer, and wherein said dusting layer is disposed adjacent said backsheet.

2. The absorbent article of claim **1** wherein said primary layer comprises a uniform combination of hydrophilic fiber material and particular amounts of discrete particles of absorbent gelling material.

3. The absorbent article of claim **2** wherein said hydrophilic fiber material consists of cellulose fibers.

4. The absorbent article of claim **3** wherein said insert core component has a top surface area from about 0.25 to about 1.0 times that of said shaped core component.

5. The absorbent article of claim **4** wherein said insert core component is positioned relative to said backsheet in a manner such that at least about 75% of the absorbent gelling material in said primary layer is found within the front two-thirds section of said absorbent article.

6. The absorbent article of claim **5**, wherein said primary layer contains from about 9% to about 60% by weight of said primary layer of discrete particles of absorbent gelling material.

7. The dual-layer absorbent core of claim **6** wherein said shaped core component consists essentially of hydrophilic fiber material and from about 0% to about 8% by weight of said shaped core component of discrete particles of absorbent gelling material.

8. An absorbent article comprising:

a topsheet;

a liquid impervious backsheet associated with said topsheet; and

an absorbent core disposed between said topsheet and said backsheet, said absorbent core comprising:

(a) a dusting layer consisting of hydrophilic fibrous material, and

(b) a primary layer consisting of a combination of hydrophilic fibrous material and particular amounts of discrete particles of absorbent gelling material airlaid over said dusting layer,

wherein said dusting layer is relatively thinner in thickness than said primary layer, and wherein said dusting layer is positioned adjacent said backsheet.

9. The absorbent article of claim **8** wherein said primary layer consists of a uniform combination of hydrophilic fibrous material and particular amounts of discrete particles of absorbent gelling material.

10. The absorbent article of claim **9** wherein said hydrophillic fibrous material comprises cellulose fibers.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,888,231 Page 1 of 2

DATED : December 19, 1989

INVENTOR(S) : JOHN J. ANGSTADT

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, Line 39,	"Dawn 1. Houghton" should read ---Dawn I. Houghton---.
Column 3, Line 31,	"Dawn 1. Houghton" should read ---Dawn I. Houghton---.
Column 3, Line 34,	"hold and distribute discharge" should read ---hold and distribute discharged---.
Column 3, Line 50,	"1008 absorbs discharge" should read ---1008 absorbs discharged---.
Column 5, Line 4,	"the term "disintegrator" s" should read ---the term "disintegrator" is---.
Column 6, Line 63,	"However, alternative preferred slitting" should read ---However, alternative preferred splitting---.
Column 9, Line 15,	"Thus it is preferably" should read ---Thus it is preferable---.
Column 9, Line 58,	"it is preferably" should read ---it is preferable--.
Column 12, Line 14-15,	rotating in a comput-er-clockwise direction" should read ---rotating in a computer-clockwise direction--.
Column 12, Line 20,	"plate 708, the inlet" should read ---plate 708; the inlet---.
Column 16, Line 1,	"stream 8" should read ---stream 58---.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,888,231

DATED : December 19, 1989

INVENTOR(S) : John J. Angstadt

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, Line 26, "disposable absorbent articles" should read ----disposable absorbent article---.

Signed and Sealed this

Sixteenth Day of June, 1992

Attest:

DOUGLAS B. COMER

Attesting Officer

Acting Commissioner of Patents and Trademarks